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Management issues and options for small scale holobenthic octopus fisheries

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ABSTRACT

Octopuses are a difficult resource to manage due to their short life span, rapid growth, high natural mortality and sensitivity to environmental conditions. These biological traits result in seasonal fluctuations in abundance and subsequent landings. Twenty two octopus fisheries were reviewed from 17 countries to examine the application and effectiveness of different management measures for consideration in the Tasmanian *Octopus pallidus* fishery in Australia. While the most commonly used measures in these fisheries were input controls, particularly seasonal closures and minimum size limits, these controls are poorly suited to semelparous, holobenthic octopuses such as *Octopus pallidus*. A semelparous reproductive strategy means that minimum size limits don't allow animals to reproduce prior to capture. A holobenthic life history strategy means that fishery-wide seasonal closures are unable to address variation in biological characteristics (e.g. size at maturity) across sub-stocks and collectively reduce effort on vulnerable life stages. Seasonal closures and minimum size limits also reduce the economic efficiency of the fleet and may diminish fishery productivity through effort displacement and serial depletion. A rotational system of effort or cap on total effort that provides flexibility to fishers and effectively spreads fishing effort, allowing different areas or sub-stocks to recover, could be a more effective option for achieving the objectives of most octopus fisheries.

1. Introduction

The commercial importance of cephalopods has increased through time due to a rise in market demand and ex-vessel prices, as well as a decline in the availability of groundfish stocks in some regions (Boyle, 1996; Caddy and Rodhouse, 1998; Rodhouse et al., 2014). This has resulted in a variety of different fisheries (both industrial and artisanal) exclusively targeting cephalopods or increasingly landing them as bycatch using a variety of different gear types in both inshore and offshore areas (Pierce and Portela, 2014; Rodhouse et al., 2014). In 2010, global cephalopod landings totalled 3.6 million tonnes (t), with most of the catch concentrated in the northwest and central Pacific, the northwest African coast, the Mediterranean and northwest Atlantic (FAO, 2014; Pierce and Portela, 2014).

Octopuses from the sub-class Coleoidea (which also includes cuttlefish and squid) comprise approximately one-third of the total number of cephalopod species (Acosta-Jofré et al., 2012) and contribute approximately 10% to the total cephalopod landings (FAO, 2014). Octopus have been termed “ecological peculiarities”, due to life-cycle characteristics that include internal fertilisation, low fecundity and parental care among adults (k-strategy traits), as well as short life cycles, rapid growth to maturity and high natural mortality (r-strategy traits) (Boyle, 1996; Pierce et al., 2008; Sobrino et al., 2002). These biological characteristics are inherently linked to local environmental conditions, which may influence hatching success and timing, larval mortality, recruitment, growth and spawning success (Moreira et al., 2011; Pierce and Portela, 2014). Consequently, the landings and catch rates of octopus have the propensity to be highly stochastic across temporal and spatial scales (Hernández-Garcı;a et al., 1998; Sánchez et al., 2004; Sobrino et al., 2011).

The short life cycle and semelparous life history strategy of octopus with a single spawning period followed by death (i.e. non-overlapping generations), complicates their successful management, as abundance highly depends on the strength of recruitment, which is vulnerable to depletion of a single year class (Boyle, 1996; Gonzalez et al., 2011). Stocks may be relatively abundant in one year

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but decline in the succeeding year due to less favourable environmental conditions and/or fishing pressure (Boyle, 1996; Boyle and Rodhouse, 2005; Rodhouse et al., 2014). There is no buffer for species with non-overlapping generations to recruitment failure in a given fishing season (Pierce and Guerra, 1994) so the size of the exploitable biomass and level of fishing mortality is critical in providing adequate recruitment levels to sustain the fishery (Boyle, 1990; Defeo and Carlos Castilla, 1998).

Determining the population size and an appropriate level of fishing mortality given the variability in recruitment can be particularly challenging for fisheries scientists, as data used in most stock assessments is not up-to-date and provides limited opportunity to adjust fishing pressure on individual cohorts within-season, increasing the possibility of overexploitation (Bravo de Laguna, 1989; Hastie et al., 2009). This may be an even greater concern in fisheries where octopus form spawning aggregations or exhibit migration patterns that can be actively targeted or predicted respectively by fishers (Tsangridis et al., 2002). Additionally, it may be more of a concern for holobenthic octopus that produce benthic hatchlings and egg batches in the hundreds, compared to merobenthic octopus that produce planktonic hatchlings and egg batches in the hundreds of thousands (Leporati et al., 2009). The dispersal potential of the former is limited, which results in more localised recruitment dynamics and a finer-scale population structure, increasing the potential for localised depletion (Higgins et al., 2013; Leporati et al., 2009).

The difficulties of using traditional stock assessment models for the purpose of assessing the stock status of these short-lived species are well recognised and have led to many stocks never being properly assessed (Hastie et al., 2009; Pierce and Guerra, 1994). Given the lack of knowledge in many fisheries concerning the biology of the species and associated ecological processes, many authors conclude that further research to inform management is required (Boyle, 1996; Narvarte et al., 2007; Pierce and Guerra, 1994). As many octopus fisheries are small-scale commercial or artisanal fisheries of low value, additional research can be cost prohibitive and lower priority than other more valuable fisheries with potential for improved management (Pierce and Guerra, 1994).

The Tasmanian *Octopus pallidus* fishery in Australia is a case in point, where further research on both the biology of the stock and environmental processes influencing its abundance is required in order to inform management decision-making. This small-scale fishery has been classified as "transitional depleting"[1] in the latest Australian fish stock status report (Emery et al., 2014) as catch rates have experienced a slow decline over the last eight fishing seasons, whilst fishing effort has risen to a record high (Emery and Hartmann, 2014). Consequently, the management of the fishery has come under scrutiny. In order to establish precautionary management strategies that ensure both ecological and socio-economic objectives are attained in the fishery, information on not just the biology of the species and associated ecological processes is required, but an understanding of what management measures and frameworks exist and have been used successfully in other international commercial octopus fisheries (Perry et al., 1999; Rodhouse et al., 2014). As octopus species share similar life-history traits (Benbow et al., 2014), the objective of this study was to review the management measures used in other commercial fisheries targeting both holobenthic and merobenthic octopuses and assess their applicability in the Tasmanian *Octopus pallidus* fishery. These findings can be readily applied to inform fisheries management of other octopus fisheries worldwide.

2. Background to the Tasmanian *Octopus pallidus* fishery

2.1. Biology of Octopus pallidus

Octopus pallidus is endemic to south-eastern Australia, ranging across 2500 km from the Great Australian Bight in the west, to around Tasmania in the south and to southern New South Wales in the east, across a wide depth range of 7–275 m (Leporati et al., 2009; Stranks, 1988, 1996). With a holobenthic life history strategy, it produces large well-developed benthic hatchlings, averaging 0.25 g that adopt an adult lifestyle after hatching (Leporati et al., 2007). *Octopus pallidus* grows to a maximum of 1.2 kg with an average life expectancy of 12–18 months. It is semelparous, dying shortly after reproducing, meaning there are likely to be non-overlapping generations (Leporati et al., 2008a, 2008b). Although a year round spawner, an optimal spawning period has been identified around late summer and early autumn (Leporati et al., 2008a). Genetic studies have identified that the stock is highly structured with discrete subpopulations in Bass Strait (less than 100 km apart), which is reflective of its reduced dispersal capability caused by a holobenthic life history strategy (Doubleday et al., 2008; Higgins et al., 2013). There is no information on the movement of *Octopus pallidus* although the genetic structure suggests that it does not undertake seasonal migrations as evidenced in other species of octopus (Tsangridis et al., 2002).

2.2. Geographic extent and operation

Established in 1980, the Tasmanian *Octopus pallidus* fishery involves a single company, operating two full time vessels that fish in Bass Strait, off the northern Tasmanian coast (Emery and Hartmann, 2014; Leporati et al., 2009) (Fig. 1). The fishing season runs from 1 March to 28 February each year, with octopus caught in moulded plastic pots attached to demersal longlines three to 4 km in length, set on the sea floor at depths of 15–85 m (Leporati et al., 2009). Currently a maximum of 1000 pots per line are allowed.

The two fishing vessels use unbaited pots that are hauled every three to six weeks to achieve optimal catch rates (Emery and Hartmann, 2014). These pots rely on the shelter seeking behaviour of *Octopus pallidus*, which require refuges to hide and brood eggs. This efficient system has enabled the commercial fishery to rapidly expand production (Emery and Hartmann, 2014; Ziegler et al., 2007).

2.3. Fishing catch and effort

Octopus pallidus landings in Tasmania have averaged around 85 (±7) t since 2005/06 albeit with some variability with a record high 117 t catch taken in 2012/13 preceded by a record low 59 t catch taken in 2011/12 (Fig. 2). Current landings are around double what they were prior to 2000 (Leporati et al., 2009). Associated fishing effort averaged around 299,900 (±14,250) potlifts between 2005/06 and 2011/12 but over the last two fishing seasons has increased to an average 425,800 potlifts (Fig. 3).

2.4. Fishery assessment and catch rates

The stock status of *Octopus pallidus* is assessed through consideration of the level of commercial catch and catch rates, as there is insufficient information in the fishery to calculate fishing

[1] The transitional depleting stock status category means that the "biomass is not yet recruitment overfished, but fishing pressure is too high and moving the stock in the direction of becoming recruitment overfished" and "management is needed to reduce fishing pressure and ensure that the biomass does not deplete to an overfished state" (Flood et al. (2014)).