Available online at www.sciencedirect.com
SCIENCE DIRECT®
Fisheries Research 71 (2005) 279–294
FISHERIES RESEARCH
www.elsevier.com/locate/fishres

Using otolith weight–age relationships to predict age-based metrics of coral reef fish populations at different spatial scales

Dong C. Lou[a,*], Bruce D. Mapstone[a,1], Garry R. Russ[b], Campbell R. Davies[a,2], Gavin A. Begg[a]

[a] *CRC Reef Research Centre at James Cook University, Townsville, Qld 4811, Australia*
[b] *School of Marine Biology and Aquaculture, James Cook University, Townsville, Qld 4811, Australia*

Received 19 November 2003; received in revised form 3 September 2004; accepted 3 September 2004

Abstract

An accurate estimate of age structure of a fish population is an important requirement of fisheries stock assessment. The conventional method of age determination, based on counts of annuli in sectioned otoliths, can be time consuming and expensive, especially in the tropics. This study assesses the use of otolith weight to predict age structures of an important exploited coral reef fish at different spatial scales (within reef, between reefs within regions and between regions), and the implications of this for estimates of key fishery parameters. Otolith weight–age relationships were estimated for common coral trout, *Plectropomus leopardus* (Serranidae: Epinephelinae), at 24 coral reefs located in four different regions spanning seven degrees of latitude along the Great Barrier Reef of Australia. Otolith weight increased linearly with age, with r^2 values of the relationships varying from 0.55 to 0.81 for individual reefs. The accuracy of predictions of age structure varied depending upon the spatial scale over which the prediction was made. Predictive accuracy was highest at the local scale of individual reefs, and worst at the largest scale of between regions. Predictions of age based on otolith weight–age relationships generally overestimated the minimum age of a population and underestimated the maximum age. Mean predicted age was generally within ±1% difference of the mean observed age, while mean predicted length at modal age (growth index) was largely within ±5% difference of mean observed length at modal age. Predictions were less accurate, however, for estimates of total mortality rate relative to those estimated from direct age estimates. Otolith weight–age relationships generally predicted modal age within ±1 year at all three spatial scales. These results have significance for making rapid, initial estimates of key parameters for stock assessment of tropical reef fish, especially for minor species or in circumstances where available resources are insufficient for a comprehensive program of direct age estimation.

Keywords: Age structure; Otolith weight; *Plectropomus leopardus*; Great Barrier Reef; Coral reef fish

* Corresponding author. Tel.: +61 747815190; fax: +61 747814099.
E-mail address: dongchun.Lou1@jcu.edu.au (D.C. Lou).
[1] Present address: Antarctic Climate & Ecosystems Cooperative Research Centre, Private Bag 80, Hobart 7001, Australia.
[2] Present address: Australian Antarctic Division, Channel Highway, Kingston Tas 7050, Australia.

0165-7836/$ – see front matter © 2004 Elsevier B.V. All rights reserved.
doi:10.1016/j.fishres.2004.09.003

1. Introduction

Knowledge of age structures of fish populations allows estimation of growth, mortality and recruitment, and thus contributes to calculations of production rates of populations (Hilborn and Walters, 1992). Conventional methods of age determination are based on the interpretation of increments in the bony structures of fish, such as scales and otoliths. These methods are generally time consuming and expensive (Cardinale et al., 2000), especially in the tropics (Russ et al., 1996). Accordingly, there is considerable interest in developing alternative, more cost- and time-effective methods of estimating fish age structures, especially for application in resource-limited situations such as apply in many tropical countries.

Recent research indicates that there is a close relationship between otolith weight and age. Such relationships have been demonstrated in numerous species of both temperate and tropical fishes. These fishes include the temperate sardines, *Sardinella aurita* (Pawson, 1990); pilchards, *Sardinops neopilchardis* (Fletcher, 1991); Atlantic and Pacific blue marlin, *Makaira nigricans* (Wilson et al., 1991); Baltic cod, *Gadus morhua*; and plaice, *Pleuronectes platessa* (Cardinale et al., 2000). In tropical waters, such relationships have been demonstrated for the damselfishes *Pomacentrus moluccensis* and *P. wardi*, (Worthington et al., 1995a); four genera of the family Acanthuridae (Choat and Axe, 1996); tropical snappers, *Lutjanus synagris* (Luckhurst et al., 2000), *L. erythropterus*, *L. malabaricus*, *L. sebae*, *L. carponotatus*, *L. vitta* (Newman et al., 2000a,b) and *L. malabaricus* (Newman, 2002); and cutlassfishes, *Trichiurus*spp., (Kwok and Ni, 2000). These studies have found that otolith weight is usually closely related to the age of the fish (r^2 ranges 0.70–0.96), meaning that otolith weight may be a useful predictor of fish age.

In addition to the use of otolith weight for estimating ages of individual fish, Worthington et al. (1995a,b) and Cardinale et al. (2000) found that otolith weight could be used to estimate age structures of fish populations. Two factors may undermine the use of otolith weight to estimate age structures, however: (a) overlap in the range of otolith weights between fish of different ages; and (b) variation in space or time (e.g. between reefs for reef fish), that alters partially the relationship between otolith weight and age. While the first factor may be overcome to some extent by frequent recalibrating of the relationship between otolith weight and age (Worthington et al., 1995a), it is likely to be a product of natural variation in growth of the fish and their otoliths and so a persistent source of uncertainty in ages predicted from otolith weights. The second factor has not been explored well in published reports and requires more extensive evaluation over broad spatial and temporal scales.

The coral trout of the genus *Plectropomus* (Oken) are members of the serranid subfamily Epinephelinae, commonly known as groupers. This genus supports important fisheries throughout the tropical and subtropical regions of the world (Levin and Grimes, 2002). On the Great Barrier Reef of Australia, the common coral trout, *Plectropomus leopardus*, is the most abundant species in the genus (Randall and Hoese, 1986) and is the primary target of commercial and recreational fishers (Williams, 2002). The Queensland commercial line-fishing fleet takes a total annual catch of 3000–4000 metric tons (t) of reef fish species per year. Coral trout comprises the largest single component of this harvest, with around 1200–1500 t caught annually (Mapstone et al., 1996a,b, 1997; Williams, 2002). Because of its importance, coral trout has been the subject of many studies investigating the abundance, size and age structure of populations (Williams and Mc Russ, 1994; Ferreira and Russ, 1995; Russ et al., 1996; Mapstone et al., 2004; Adams et al., 2001). Annuli in the otoliths of coral trout have been validated (Ferreira and Russ, 1992, 1994) and age has been estimated by counting annuli in sectioned otoliths (Ferreira and Russ, 1995; Russ et al., 1996, 1998; Mapstone et al., 2004; Adams et al., 2001). A faster and more economical method of predicting the age structures of coral trout, and other tropical species would be of particular significance to studies investigating the dynamics of these populations and their responses to fishing pressure.

In this study, we investigate the stability of relationships between otolith weight and age in common coral trout (*P. leopardus*) at three spatial scales (within reefs, between reefs within regions and between regions). We examine the implications of using otolith weight for predicting age structure of coral trout across different spatial scales by comparing the estimates of key population parameters using direct age estimates with those based on ages predicted from otolith weight–age relationships derived from fish sampled at the same and other reefs.