Marine Policy 60 (2015) 182–185

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

International workshop on methodological evolution to improve estimates of life history parameters and fisheries management of data-poor deep-water snappers and groupers

ARTICLE INFO

Keywords:
Etelis
Pristipomoides
Hyporthodus
Epinephelus
Otolith
Reproduction
Ageing protocols

ABSTRACT

Knowledge of both the life history characteristics and catch and effort statistics of exploited deep-water fishes such as snappers and groupers is typically limited. This contributes to increased uncertainty in stock assessments and, depending on the diligence in governance, is more likely to result in either highly conservative or unsustainable management arrangements. Developments, challenges and advances in the methods for obtaining life history data for these species were discussed at a workshop in May 2015. The key points raised included nascent methods for otolith sectioning and interpretation, the need for standardised international ageing protocols and the issues and challenges in characterising reproductive maturation, including during non-spawning months due to resource limitations. Strategic research directions are identified to address knowledge gaps and thus better inform fisheries management.

1. Introduction

Deep-water tropical fishes support locally significant and/or highly valued commercial and recreational fisheries, and culturally and economically important artisanal and subsistence fisheries throughout the Indo-Pacific region. In many areas there has been a gradual shift or displacement of fishing effort by commercial, recreational and artisanal fishers to deeper waters, often as a result of declines in the abundance of many inshore shallow water demersal fish species (e.g. [14,15]). Most deep-water fisheries are small-scale and typically only supply local markets. However, catch estimates are highly uncertain because the spatial and social complexity in these fisheries makes it difficult to obtain basic catch and effort data. Reliable annual catch estimates are limited to only a few long established commercial fisheries operating in the jurisdictions of Western Australia (∼791 t; [13] the Northern Territory of Australia (∼626 t; T. Saunders pers. comm.), Hawaii (∼106 t; [6]) and Tonga (∼183 t) which are annually valued at approximately USD 6.25 M, 4.95 M, 1.5 M and 1.5 M respectively. The main species captured by these fisheries are deep-water snappers (Lutjanidae) and groupers (Epinephelidae).

The limited catch and effort data defines most deep-water snapper and grouper fisheries as data-poor. Given the paucity of available data, in association with limited management capacity, funding and resources, there have been few quantitative assessments of the status of stocks across the region [18]. Life histories of most deep-water fishes are characterised by extended longevities, slow growth, late maturity, and low fecundity, indicating low production potential and resilience. As such, populations of deep-water species are vulnerable to relatively lower levels of exploitation. Developing the capacity to regularly assess stock status is needed by local fisheries management agencies. Establishing reference points from life history and fishing mortality indicators has been proposed as one approach for the regular assessment of stocks. Applying such indicators requires reliable information on the age structures, growth, longevity and reproductive biology of deep-water snapper and grouper populations.

Nascent information on the life history of this group of species (e.g. [15,17,20]) suggests that many past estimates of longevity, growth and maturity are unreliable and that there is a clear need for much of the life-history information to be reassessed, revised, and updated (see [19]). In May 2015, an international workshop was held to develop standardised methods for estimating life-history parameters for deep-water tropical snappers and groupers. The workshop brought together fisheries scientists from across the Indo-Pacific region that have responsibility for deep-water demersal fisheries research, assessment and the provision of management advice in their respective localities. The aim of this workshop was to improve our understanding of the processes required to revise important life history parameters and related data-limited methods for determining stock status to better inform fisheries managers.

2. Developments in life history research methods – age and growth

A number of the methods used to derive age estimates for these deep-water species have not been effective in contributing to accurate and precise age estimation. These methods have contributed to the systematic under-estimation of fish age in many instances and/or have questioned the feasibility of deriving reliable age estimates [2]. The techniques available for otolith preparation, section enhancement and age estimation are continually improving. In light of these improvements and developments, species that were previously thought to be difficult to age need to be re-evaluated.

Fish age is most commonly and reliably estimated from counts of growth increments in transverse sections of otoliths (e.g. [8–12,15,17]). However, there is considerable inter- and intra-specific variation in annual otolith increment readability, with the process of sectioning being primarily responsible for determining

http://dx.doi.org/10.1016/j.marpol.2015.06.020

the clarity of such growth zones and hence the ability to interpret otolith micro-structure. Development areas that may improve readability include optimal section thickness (involving thinner sections, e.g. ~200 μm, but is also species-specific and specific to the microscopy equipment available), quality control for consistent cutting orientation (e.g. transverse sections through the primordium perpendicular to the sulcus acusticus), calibration of sectioning equipment (e.g. micrometre increments on a low-speed diamond saw), post-section enhancements (e.g. immersion solutions such as dilute acid, like 2% HCl), and interpreting growth zone formations in otolith sections relative to life history characteristics (e.g. a relatively short annual spawning period infers consistency in the incremental width from the primordium to the first opaque zone which may be used as a reference; and variations in characteristics between pre- and post-maturation growth zones). The production of good quality otolith sections is crucial to improving interpretation of otolith increments and obtaining consistent annuli counts for age estimation, which underpins accurate age derivation for stock assessments and determining sustainable management strategies.

In addition, there is increasing evidence that the growth of deep-water snappers and groupers typically exhibits a relatively protracted asymptote, which suggests length and age are decoupled and hence length is not indicative of age [12,2,15,17]. This decoupling specifies that length-age keys for converting length compositions into age composition data, which may often be used in data-poor situations, are generally unsuitable and inappropriate. As such, age-based rather than length-based stock assessments are more appropriate for long-lived deep-water fishes. However, it was noted that correlating otolith morphometrics with fish age may provide a robust assessment technique in those counties and/or territories that do not have the resources for more detailed assessments [20].

Importantly, the design of sampling strategies for otolith collections will need to be cognisant of the decoupling of age and length with a further need to consider separate strategies that facilitate either: 1) estimates of age-based life history parameters (e.g. growth parameters or age at maturity, by sampling across the length and age range, stratified by time of year); and/or 2) representative sampling to derive an age composition of the stock (i.e. spatial, temporal and vessel stratification); noting that sampling strategies for both life history data and representative age composition data can overlap.

To ensure the validity of age estimation, there is a critical need to develop standardised ageing protocols for the different species of deep-water snappers and groupers. These documents need to consider i) recent advances in methods for otolith sectioning, ii) otolith section interpretations (including defining the increment widths of early growth zones as a reference to assist interpretation), iii), assessing the level of ageing precision that is acceptable (e.g. the index of average percent error, [5]) for multi-reader comparisons, and associated reader bias/drift testing, iii) development of appropriate otolith reference collections, iv) documentation of explicit examples where ageing error was identified to avoid similar misinterpretation of increments, v) the integration of information on capture and birth dates and otolith margin analysis to provide more precise decimal-age estimates, and vi) exploration of the empirical relationships between age-based growth and maturity parameters to provide additional corroboration of age estimates.

Ageing protocols must also consider and include processes for age validation. For example, validation techniques such as bomb radiocarbon dating have served to confirm age and longevity estimates for deep-water snapper and grouper species [1–3]. While bomb radiocarbon dating has proven robust for most circumstances in the mixed layer of tropical seas, using multiple criteria in a multivariate framework for an additional level of objectivity in age validation needs to be assessed. This could include using objective criteria across multiple age validation proxies (e.g. bomb radiocarbon in association with Cs^{137} and Sr^{90}). An additional approach within bomb radiocarbon dating has been described for validating the age of fish with birth years more recent than the period of rising levels of bomb radiocarbon (late 1950s to late 1960s). This approach utilises the bomb radiocarbon post-peak decline period (typically more recent than 1980). This approach was successful in the Gulf of Mexico [3] and is currently being applied to other species in Hawaii. However, this method requires a strong slope to be present in the post-peak decline period and appears to be limited to the northern hemisphere due to air-sea exchange rates (e.g. [3]); the bomb radiocarbon signal in the southern hemisphere is attenuated and phase-lagged with a long unusable peak period (e.g. [1,4]).

The ageing protocol should seek to formulate an international framework that underpins the derivation of fish age for deep-water snappers and groupers globally. The development of best practise protocols for the production of quality-assured fish age data will provide an opportunity to refine life history parameters to better inform stock assessments for improved fishery management.

3. Developments in life history research methods – reproduction

In general, there is a relative paucity of reproductive information available for many deep-water snapper and grouper species. Major issues and challenges evaluated at the workshop included characterising reproductive schedules (length-at-initial maturity in gonochoristic snappers and protogynous groupers, size-at-sex change in groupers). One of the key challenges in reproductive biology is the ongoing need to classify fish as either immature or mature. It was generally acknowledged that estimating median body length-at-maturity (LM_{50}) in eteline snappers is unequivocal if sufficient numbers of fish are available for histological examination of gonads during spawning periods. However, one difficulty complicating LM_{50} estimation for female snappers, as for most fishes, is distinguishing immature fish from resting-mature fish during non-spawning periods. This is especially difficult for stocks in which the spawning period is very restricted and maturity while inactive is assessed using only conventional criteria such as the definitive evidence of ephemeral post-ovulatory follicles and atretic yolked oocytes.

The use of additional histological criteria (e.g. developmental stage of ovarian lamellae, subtle morphological features of previtellogenic oocytes) needs to be explored. One possibly novel histological criterion for maturity in ovaries during non-spawning months (apparent yolk granules embedded in support tissue of ovarian lamellae) was identified at the workshop for pygmy ruby snapper, *Etelis carbunculus*[1] in Hawaii, but further evaluation is needed for this species and a congener (flame snapper, *E. coruscans*) in Hawaii and for both species plus a third congener (giant ruby snapper, *E.* sp.) elsewhere in the Indo-Pacific. In general, consistent and objective (quantifiable) histological criteria for maturity need to be developed, accepted, and formally adopted, both to standardise results across species, fisheries, and jurisdictions and to facilitate valid spatial comparisons within species.

[1] Note that molecular data has contributed to a taxonomic revision that has concluded that *Etelis carbunculus* is the correct scientific name for the pygmy ruby snapper recently referred to as *E. marshi*, and that *E.* sp is used to refer to the giant ruby snapper recently referred to as *E. carbunculus* (e.g. see previous nomenclature used in [16]).