SQUID: SUMMARY OF RESOURCE AND FISHERY, AND ON IMPROVING THE ASSESSMENT MODEL

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History

Originally squid provided only a bycatch in the demersal trawl fishery on the South African south coast. However, a directed jig fishery commenced in 1985, and has since provided the major component of the total catch.

The fishery is managed under a fixed effort harvesting strategy, with the associated TAE (expressed as person-days and currently set at 295 000 person-days) adjusted every few years in line with assessment updates. However, this effort is not directly allocated amongst right holders. Each commercial vessel has a crew complement, the total of which amounts to 2443 crew for the entire fleet. The reporting of detailed records of the effort expended is often delayed so that a coarse early warning system has been developed; this serves as a basis to curtail fishing as the end of the fishing season approaches it appears that the TAE is likely to be exceeded.

The Appendix provides some summary comments by the Squid Scientific Working Group on squid biology and the operation of the fishery.

There are two closed seasons:

i) A “permanent” closed season of five weeks centred on November, which corresponds to the peak spawning period, the objective of which is to limit the disturbance of fishing on spawning aggregations.

ii) An “additional” closed season, typically of three months duration and usually over the April-June period. This became necessary because, given the number of rights allocated in the fishery, the TAE will be exceeded if all rights holders operate at approaching their full capabilities (some vessels operate for up to 220 days per annum). The start of this additional season may be advanced or delayed early in the calendar year if it appears that the TAE is likely to be reached before this date, or alternatively, may not be reached by then.

iii) This situation is currently in flux, as 15% of the squid rights (i.e., the number of fishers) have recently been transferred to small-scale fishers.

Assessment

Document [SQUID/P2] details the current assessment approach and how this is used to provide a value for the TAE for the jig fishery. (This approach was last reviewed by the IWS Panel in 2012). Note that the criterion used to determine the TAE (see pg 5 and Fig 10 of SQUID/P2) is a probability of 5% of the biomass falling below 20% of its pristine level in any future year.

Key features of the current assessment model are:

- Core inputs are past catches plus abundance indices from the trawl and jig fisheries, as well as input from hake-directed research surveys.
- A general lack of contrast in the data renders precise parameter estimation problematic, especially for pristine abundance.
- A key feature is that the trawl bycatch CPUE dropped concurrent with the introduction of the jig fishery (see SQUID/P2 Figs 5 and 6).
- The assessment model "explains" this by assuming that the jig fishery disturbs the spawning aggregations, with a consequent reduction in recruitment.

Revision of the assessment at this time is considered appropriate for three reasons:

1) As indicated in the Appendix, squid is now considered not to live beyond about one year, contrary to what is assumed in the current assessment.
2) This "annual" cycle needs to be taken into account consistently in the definition of the overall season and the assessment of the resource.
3) The introduction of further rights (allocated to small-scale fishers) could well bring problems of TAE overruns, and hence difficult debates over the appropriateness of that TAE and the model used to determine its value, rendering pre-emptive addressing of this issue desirable.

Key aspects of the planned assessment revision

The points following have been drawn from discussions in the Squid working group, and have also been informed by discussion points tabled at one of their meetings [MARAM/IWS/2022/SQUID/P2].

1) The underlying model is to continue to be gender-aggregated and assuming a single stock, as there is insufficient information to advance further on those fronts at this stage.

2) Senescence is to be introduced in the thirteenth month of life to ensure that a squid does not live beyond 13 months (although a small proportion of squid can live to an age of about 14 months, this is seen as an adequate approximation)[1].

3) In the current assessment model, somatic growth and natural mortality (*M*) are combined into a single parameter, *g*. In the revised model, month-specific *g* factors are to be applied so that by the end of the 13th month all squid in a month-specific cohort have died.

4) In the current assessment model, recruitment is assumed to occur in January, following which the squid immediately join the exploitable biomass and are included in the survey biomass estimate. Instead, it is planned that spawning and recruitment be spread over a nine-month period from May to January. Squid born in a particular month would not be available to the fishery for the next eight months. Over months 9-13 they then become available to the fishery, after which they die (achieved by diminishing the sizes of the nine "month" sub-cohorts by fishing mortality and the *g* factor).

5) Recruitment (in annual aggregate) is planned to be modelled as varying annually, and being apportioned by month over the May-January period according to a year-invariant estimable pattern.

[1] Lipinski LR, Mwangombe CH, Durholtz D, Yemane D, Githaiga-Mwicigi J, Sauer WHH. 2020. Age estimates of chokka squid *Loligo reynaudii* off South Africa and their use to test the effectiveness of a closed season for conserving this resource. *African Journal of Marine Science*. 42:4, 461-471.

6) The fishing periods are be split as follows: October-January (the period during which the highest effort levels are applied) and February-September. The CPUE and model dynamics will also be split accordingly. Details of this still need discussion – ideally effort might be month-specific, but there may not be adequate data to allow for estimation at that level, so that rather a fixed ratio of the effort applied in these two periods will be estimated.

7) The present fishing season is May to April (though usually April to June are included in the additional closed season). Though somewhat messy, given that monthly patterns in recruitment and fishing effort differ, this would seem able to be accommodated in the new assessment structure. For administrative purposes in particular though, it is important that the season end is specified clearly, and that roll-over of effort (in either direction) across the end of the season is not permitted. This is because this would be inconsistent with the underlying structure of "near-independent" fisheries from season to season, based on differing recruitments to an annual species and regulated by fixed effort control.

8) A matrix of alternative values of steepness (*h*) and the (aggregated over a year) *g* parameter will be considered to compare the respective –lnL values for assessments for each of these combinations. From past experience, it seems unlikely that this exercise will have much success at discriminating amongst these values.

9) An acoustic method [MARAM/IWS/2022/SQUID/BG1] is under development which is planned to monitor annual estimates of (a geographically fixed part of) the squid biomass at a fixed time late in each year. Pilot surveys covering part of the inshore spawning grounds were carried out in 2019 and 2020, and a full survey, covering the whole ground in multiple phases was completed in 2021. A further full-scale survey has recently been completed. Although it will likely be a few years yet before reliable results come on-line (and especially a time series long enough to inform meaningfully on trends), consideration needs to be given to how those results may come to be used. Three possibilities have been raised.

i) The estimates will be absolute (though for only a part of the resource). This might provide at least a "red-face test" check on scale for the abundance estimates output by the assessment model.

ii) A series of these estimates would provide an additional index of relative abundance to which to fit the assessment model.

iii) Such estimates could provide a basis for a more complex (but more utilisation-efficient) harvesting strategy, which could modify the TAE during the season up or (in extremis) down in line with the abundance indicated (similar to the current approach used to increase the anchovy TAC in mid-season if the recruitment survey yields sufficiently positive results). A difficulty though is the lateness in the time during the season when such a result would be likely to come available.

Key question (request) to the Panel

Provide comments relating to improvements, corrections and extensions to the suggestions made for the new squid assessment model.

Documents

Primary papers

MARAM/IWS/2022/SQUID/P2: J.P. Glazer. 2019. Updated assessment of the squid resource, *Loligo reynaudii*. FISHERIES/2019/MAR/SWG-SQ/06.

An assessment of the squid resource was last undertaken in 2016 and at that time included data to 2015. An additional 2 years of data are now available, and these have been included in an updated assessment. A Bayesian analysis has been conducted and projections 10 years into the future suggest that effort in this fishery could be increased to 295 000 person-days.

MARAM/IWS/2022/SQUID/P3: Anon. 2022. Squid assessment discussion points.

This document lists various discussion points raised by the Task Group in 2021.

Background paper

MARAM/IWS/2022/SQUID/BG1: I Hampton, M.A. Soule and J. Mwicigi. 2022. Summary of acoustic work to assess the biomass of the aggregated chokka squid on its inshore spawning grounds on the south-east coast of South Africa in the season closed for fishing.

Recent attempts to estimate the biomass of aggregated squid on the inshore fishing ground by acoustic surveys in November, when the fishery is closed for conservation purposes are described in this document.

Appendix

Summary comments by Squid Working Group on Squid biology and the associated fishery

- Chokka squid typically hatch around 30 days after being spawned, although this "incubation" period can be highly variable depending on ambient temperature.

- Growth is rapid, with individuals attaining recruitment size (i.e. size at which they start appearing in jig catches, which is about 150 mm mantle length) in about 250 days (roughly 8 months).

- Although the primary spawning period is in summer (starting in August, peaking in the October – December period and extending through to late January/early February), there appears to be a "minor" winter spawning period as well (extending from May through to late July). These observations suggest that the first, "winter-spawned" group of squid (i.e., spawned during May) would hatch during June and then start recruiting to the fishery about 8 months after hatching (i.e., February the following year), with squid spawned during the summer period then recruiting to the fishery from May the following year onwards.

- Given these observations, squid from a given "cohort" (encompassing both winter- and summer-spawned components) would be mainly exploited by the jig fishery from March through to about April the following year. The current fishing season (1 May – 31 April the following year) aligns with this reasonably well.

- Little information exists regarding the male versus female ratio in the squid catch. This needs further investigation.

- The catching of squid is mainly driven by monthly effort peaks between October and January, with fewer squid being caught between February and September.