SPRFMO
South Pacific Regional Fisheries Management Organisation

ASSESSMENT SIMULATION TASK TEAM FOR THE JUMBO FLYING SQUID IN THE SOUTHEASTERN PACIFIC OCEAN

Terms of Reference and Workplan

SUMMARY

Strong evidence of the complex population structure of the jumbo flying squid (*Dosidicus gigas*) in the Eastern Pacific Ocean exists. Three morphotypes with different size ranges, maturity sizes, and spatial distribution have been described for this species. Currently, three stock assessment models are under discussion in the context of the SPRFMO. However, these models currently do not take into account the biological and ecological knowledge of the species. For these reasons, an Assessment Simulation Task Team (ASTT) for the jumbo flying squid assessment with simulated data was proposed during SC11 and approved at COMM12 (COMM12-Doc06), with a reporting cycle for 2024 and 2025. The objective of the ASTT is to test the robustness of potential assessment models to the multiple uncertainties in the population structure of jumbo flying squid and the impact of the data availability in the performance of the assessment. The simulated assessment will provide understanding of the uncertainties associated with the assessment of Jumbo Flying Squid and the impact in the management measures for this resource within the SPRFMO area.

1. Introduction

The assessment of cephalopods on a global scale is currently impeded by the life history of this resource and the paucity of information available from fisheries. The aforementioned species possess a number of distinctive biological characteristics, such as high phenotypic plasticity, rapid growth and a comparatively short lifespan. As a consequence of these attributes, it proves particularly challenging to develop a modelling tool that attempts to reproduce their population dynamics in a manner that more closely resembles reality (Arkhipkin et al. 2021), even more if there is evidence of a complex population structure as in the case of the jumbo flying squid *Dosidicus gigas* (Arguelles et al. 2001, 2017, 2019, 2019, 2023a, 2023b, Csirke et al 2018, Fang et al 2017, Gretchina & Zúñiga 2017 and 2018, Nigmatullin et al. 2001, Payá 2019, Xu et al 2018). The jumbo flying squid in the Eastern Pacific Ocean presents high variability in size at maturity, as was described by Nigmatullin et al. (2001) where three groups with different size ranges, maturity sizes and spatial distribution are mentioned.

Despite these difficulties, within the framework of the SPRFMO, efforts have been made to implement models that attempt to reproduce the population dynamics of *D. gigas*. Within the SPRFMO Jumbo Flying Squid Working Group, preliminary assessment models have been presented (China: Xu et al 2018 - SC6-SQ06, Peru: Cordue et al. 2018 - SC6-SQ07, Chile), which necessitated the incorporation of biological data (e.g., size, maturity) throughout its distribution area. Subsequently, three models presented during SC 10 (SPRFMO SC10-Report 2022) were discussed. To date, three models are under discussion (Payá 2023 SC11-SQ07, Li et al. 2023 SC11-SQ08 and Roa-Ureta and Wiff 2023 SC11-Obs03). However, a limitation of these models is that they operate on the assumption of a single population with identical longevity, length at maturity, growth rate, and natural mortality across the extensive range of the jumbo flying squid's distribution.

The Assessment Simulation Task Team (ASTT) for the jumbo flying squid assessment with simulated data was proposed during SC11 and approved at COMM12 (COMM12-Doc06), with a reporting cycle for 2024 and 2025. The ASTT will assess the robustness of the proposed models to the various uncertainties inherent to the population structure of the jumbo flying squid. This will entail an investigation into the existence of at least three clearly differentiated morphotypes in the southeastern Pacific, as proposed by Arkhipkin et al. (2021). Additionally, the ASTT will elucidate the uncertainties associated with the utilisation of potential assessment models and their implications for the management of the resource. This document sets forth the objectives of the group and its terms of reference for the activities of the group.

2. Terms of Reference

The objective of the ASTT is to test the robustness of the potential assessment models to the multiple uncertainties in the population structure, unique biological and life history characteristics of jumbo flying squid and the impact of the data availability in the performance of the assessment.

The Jumbo Flying Squid ASTT has the following Terms of Reference (TR):

1. Generate simulated data consistent with the requirements described in the next session.
2. Elaborate a protocol for the comparison of assessment models for the jumbo flying squid stock assessment in the Southeastern Pacific.
3. Apply this protocol for the comparison of candidate assessment models.
4. Produce a realistic simulation model of the population dynamics of the jumbo flying squid in the Southeastern Pacific for its future use as operative model in a management strategy evaluation (MSE) context.
5. Report the results to the Scientific Committee

3. Simulated data requirements

The simulated data should fulfil the following requirements:

Biology: to reproduce the different morphotypes of jumbo flying squid identified in the Southeastern Pacific (Nigmatullin et al. 2001), considering their differences in both growth and size at first maturity, and to mimic the semelparous biological trait and high natural mortality after spawning of the species.

Ecology: to consider ontogenetic migrations and spatial distributions of different phenotypes reported in the literature (e.g. Csirke et al. 2015, Hu et al. 2022), as well as the high degree of cannibalism observed in this species. To consider the effect of climate variability on key parameters related to the life history of this species (e.g., growth, natural mortality, among others).

Fisheries: to take into account the differences in selectivity among the various fleets operating on this species in the Southeastern Pacific, both at the size level (e.g., offshore vs. inshore fleets) and sex level (e.g., trawl vs. jigging).

Sampling: to consider different uncertainty scenarios associated with different levels of sampling effort (e.g., observer coverage, number of ports sampled).

Data reporting: to produce both aggregate statistics (i.e., catches, average sizes) and disaggregated data by size, fishing area, and fleet type, consistent with standardization of sampling effort among Members.

4. Simulation plan

4.1. Population structure

One population, common spawning ground with spatial structure.

H1.0: Just one morphotype (control)

H1.1: Three morphotypes (small, medium and large) are spatially defined (space is a good proxy of environment but constant)

H1.2: Three morphotypes (small, medium and large) are environmentally defined (more than one phenotype is possible to be observed in some areas).

<u>Each morphotype has its own set of parameters (growth, mortality and reproduction).</u>

4.2. Fisheries structure

H2.1 Two fisheries: Artisanal (Peru, Ecuador and Chile) and industrial (high seas)

H2.2 Four fisheries: Equatorial + Peru + Chile + High Seas

Each fishery has its own set of parameters (fishing mortality and gear selectivity).

- Time variability in fishing mortality for each fishery will be simulated consistently with historical trends.

4.3. Parameter Uncertainty

Parameter	Value	
	CONSTANT	SCENARIOS
	One value per ontogenetic stage (e.g. gnomonic model, definition of stages is important). Higher in the high seas (1 o.m.), lower in coastal areas. **Check: SC7-SQ07, SC6-SQ06.**	**Variability given by the environment (PCTI, Humboldt Current Index, use several). Smooth variation, not only on/off.** **Check: SC11-OBS04, SC11-SQ03**
Reproduction/ Recruitment	Peak in austral spring/summer, spawning all year (medium and large). Relative fecundity different by morphotype. Total fecundity is different by morphotypes. Maturity norm different by morphotype. SR: steepness by morpho Stock-Recruitment specific for cephalopods, do not use BH. Ricker to Shepherd. Check Ibañez et al. (2015)	Squid matures at smaller sizes during El Niño.
Growth	Schnute model One growth curve by morphotype	As with mortality
Gear Selectivity	By fleet High seas: different for Chinese (equatorial) **Asymptotic selectivity, by fleet.**	

All parameters will include process error, possibly with temporal autocorrelation.

4.4. Data collection and availability uncertainty

	H4.0 (perfect information) monthly	H4.2 (current)	H4.3 (near future)
Catch (total)	X (no error)	Monthly	Monthly
Catch (by fleet)	X (no error)	Monthly	Monthly
Catch-at-length (total)	X (no error)	-	-
Catch-at-length (by fleet)	X (no error)	Only for high seas, daily	All fleets
Average catch length (total)	X (no error)	-	-
Average catch length (by fleet)	X (no error)	Only for high seas, daily	All fleets
CPUE (by fleet)	X (no error)	Year	Year
Fishing Effort	X (no error)	-	Month, all fleets
All environmental indices used	X	X	X

5. Workplan

<u>2023-2024: Report to SC 12 (2024)</u>

First coordination meeting (10-JUN-2024)

Agenda for In-person ASTT workshop (25-27 September 2024, Lima-Perú)

- Adoption of terms of reference
- Discussion on implementation of Operating Models (TR 4)
  - Environmental effects
  - Uncertainty quantification
- Scenarios for the generation of simulated assessment data (TR 1)
  - Population and fisheries structure
  - Parameter uncertainty
  - Data collection and availability uncertainty
  - Environmental scenarios and climate change
- Protocol for the comparison of assessment models (TR 2)
- Draft of report for SC (TR 5)

<u>2024-2025: Report to SC 13 (2025)</u>

First coordination meeting (Early 2025)

Final simulated datasets (End of March 2025)

Second coordination meeting (Early April 2025)

Start of Simulated Assessment (April 2025)

Agenda for In-person ASTT meeting (Early July 2025)

- Presentation of assessment models
- Discussion on the results of the simulated assessment (TR3)
- Discussion on improvements to operating models (TR4)
- Draft of report for SC (TR5)

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