

Stock assessment of the deep-sea pink shrimp *Parapenaeus longirostris* (Lucas, 1846) of the algerian coast (Western Mediterranean).

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Résumé

Cet article présente l'application du modèle stochastique de production SPiCT (*Stochastic Production model in Continuous Time*) pour l'évaluation du niveau d'exploitation du stock de la crevette rose (*Parapenaeus longirostris*) le long de la côte algérienne (GSA04).

L'évaluation repose sur une série chronologique de données de captures, d'effort de pêche et d'indices d'abondance issus des campagnes d'évaluation des ressources démersales (ALDEM). Les données incluent les statistiques de production de la base de données FAO (1970–2000), les statistiques officielles de captures (2000–2023) fournies par le Ministère de la Pêche et des Productions halieutiques (MPPH), l'effort de pêche exprimé en nombre d'unités actives (2000–2023) et en nombre de sorties (2003–2023), ainsi que les indices d'abondance obtenus lors des campagnes ALDEM menées par le CNRDPA entre 2012 et 2023.

Le modèle SPiCT a permis d'obtenir un diagnostic sur l'état d'exploitation du stock de la crevette rose. Les résultats indiquent que ce dernier se trouve dans un état d'exploitation soutenue, avec une biomasse supérieure au rendement maximal durable (B_{MSY}) et une mortalité par pêche (F) excédant le niveau correspondant au rendement maximal durable (F_{MSY}). Une réduction d'environ 10,94 % de la mortalité par pêche permettrait de prévenir une diminution significative de la biomasse et de favoriser une gestion durable du stock.

Mots clés : *Parapenaeus longirostris*, crevette rose, évaluation, modèle de production, SPiCT.

Abstract

This study presents the application of the stochastic production model SPiCT (*Stochastic Production model in Continuous Time*) to assess the exploitation status of the deep-sea pink shrimp (*Parapenaeus longirostris*) along the Algerian coast (GSA04).

The assessment is based on a time series integrating catch, fishing effort and abundance index data derived from demersal resource assessment surveys (ALDEM). The dataset includes production statistics from the FAO database (1970–2000), official catch statistics (2000–2023) provided by the Ministry of Fisheries and Fishery Production (MPPH), fishing effort expressed as the number of active units (2000–2023) and number of fishing trips (2003–2023), as well as

abundance indices obtained from ALDEM surveys conducted by the CNRDPA between 2012 and 2023.

The SPiCT model provides a diagnosis of the exploitation level of the shrimp stock. The results indicate that the stock is under sustained exploitation, with biomass levels higher than the biomass at maximum sustainable yield (B_{MSY}) and fishing mortality (F) exceeding the level corresponding to the maximum sustainable yield (F_{MSY}).

Reducing fishing mortality by about 10.94% would reduce the risk of decrease in biomass promote the long-term sustainable management of the stock.

Key words: *Parapenaeus longirostris*, deep sea pink shrimp, Stock assessment, production model, SPiCT.

1. Introduction

The stock assessment of fish stocks with limited data remains challenging, as detailed biological information is often unavailable. In such cases, surplus production models, like SPiCT, offer a practical and alternative solution for estimating the fishing effort that maintains long-term stock productivity at the Maximum Sustainable Yield (MSY). SPiCT considers uncertainty, observation and process errors, seasonal variability, and allows the use of prior information, providing a solid basis for sustainable fisheries management (Pedersen and Berg, 2017; Kimoto et al., 2023). The current study applies SPiCT to the deep-sea pink shrimp (*Parapenaeus longirostris*) in GSA 04, a commercially important species with a wide bathymetric range (100–600 m) and optimal abundance between 300 and 400 m (Nouar, 1985; Ainouche, 2009; Ainouche and Nouar, 2023). This species is targeted by trawlers with many other commercially valuable species, as Hake *Merluccius merluccius*, Red mullet *Mullus barbatus*, Greater forkbeard *Phycis blennoides*, and red shrimp *Aristeus antennatus*.

The aim of this study is to assess the stock of the deep sea pink shrimp in GSA04 and to estimate references point for management.

2. Materials and methods

2.1. Study area

This study was conducted as part of the annual participation of the expert of the CNRDPA in the Working Group on Stock Assessment of Demersal Species (WGSAD) in framework of the FAO/GFCM. The assessment covers the entire area of GSA 04 considering that the stock of the deep pink shrimp (DPS) *Parapenaeus longirostris* in the GSA 04 is one stock unit (Figure 1).

Trawlers targeting *Parapenaeus longirostris* operate mostly on fishing ground localized between 200 and 500m depth. The configuration of the continental shelf is different along the Algerian coast. Continental shelf is narrower and very rugged in the central region, and extends a bit further to the east and west.

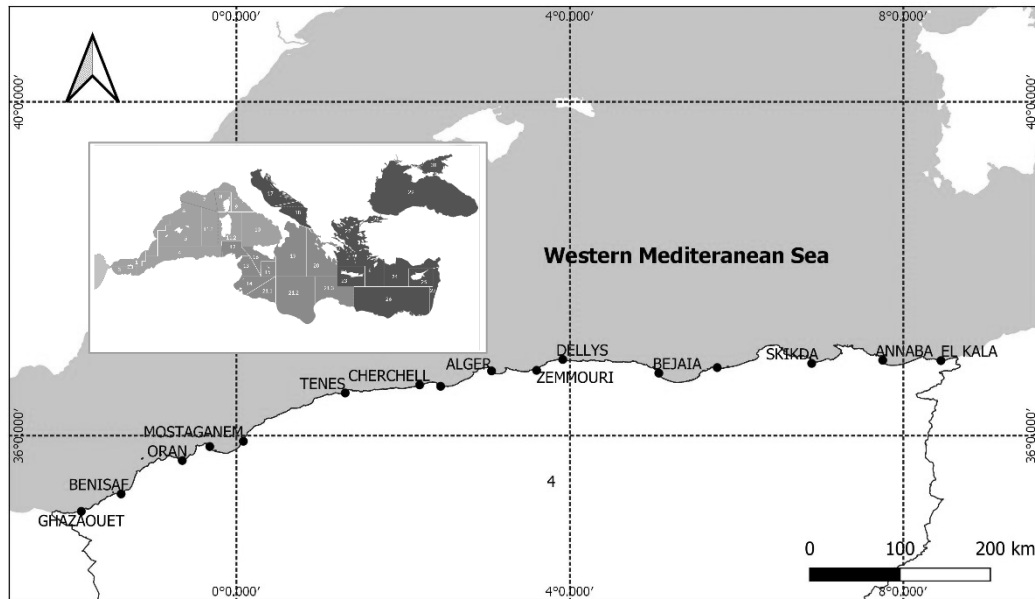


Figure 1. Study area.

2.2. Input data and model parametrization

Pedersen and Berg (2017) presented a stochastic surplus production model in continuous time (SPiCT), which incorporates dynamics in both biomass and fisheries and observation error of both catches and biomass indices, and based on the generalized surplus production model, known as the Pella-Tomlinson (1969). The model has a general state-space form that can assume uncertainty using process and observation-error as well. This model also can consider seasonal patterns in fisheries dynamics and allows setting priors on the parameters. Model equations are well described in Pedersen and Berg (2017) and Cousido-Rocha *et al.* (2022). A SPiCT R-package was developed by Pedersen *et al* (2023).

The input data are:

- **Time series of Catch data:** 1970 to 2023 (provided from FAO data base collection and national official data from 2000). The model was applied using both a long (1970 to 2023) and a

short time series (2003 to 2023) of catches.

- **Biomass survey index (kg/km^2):** This index provides from the trawl survey ALDEM carried yearly along the Algerian coast following the MEDITS protocol (Bertrand 2002, MEDITS 2017) since 2012 to 2023.
- **CPUE₁ (kg per fishing days):** is the catch(kg) divided by number of fishing days from 2000 to 2023.
- **CPUE₂ (kg per vessel number):** is the Catch(kg) divided by the vessel number from 2003 to 2023.

Four scenarios were run integrating different combination of input data:

- **Scenario 1:** Long time series of catch (1970 to 2023) only.
- **Scenario 2:** long time series of catch (1970 to 2023), biomass index, add observation error and CPUE₂(Kg/vessel).
- **Scenario 3:** Catch, biomass index (kg/km^2), CPUE₁ (kg/days) and CPUE₂ (kg/vessel).

- **Scenario 4:** Short time series of catch (2000 to 2023), CPUE₁ (Kg/vessel) and biomass index (Kg/Km²).

Additionally, the model takes as parameters: priors (r prior, bk fraction), process error (Pe) and observation error (Oe). These errors are assumed by the model related to the catch and the biomass index.

The value of r prior for *P. longirostris* is equal to 1.4 and provide from the sealife data base (Froese and Pauly, 2025). The Bk fraction is a parameter which refers to the proportion of the initial stock biomass (B₀). Some criteria must be respected to validate the SPiCT output and the steps are as follow:

First, run the predefined scenarios (1 to 4 in our case), then select only those scenarios that converge. Once the scenario converged, we conduct the model diagnostics, the hindcasting and the retrospective analysis for the converged one only.

2.3. Model diagnostics, hindcasting and retrospective analyses

Model diagnostics were conducted to assess the goodness of fit and reliability of the SPiCT model. Residual plots and statistical tests were used to verify the absence of bias, temporal trends, or autocorrelation, ensuring that the model adequately captured the observed dynamics.

A hindcasting analysis evaluated the model's predictive performance by sequentially omitting recent years, normally the 05 recent ones, and predicting them from earlier data. The predictive skill was quantified using the Mean Absolute Scaled Error (MASE), with values below 1 indicating satisfactory forecasting ability.

A retrospective analysis was also performed to examine the stability of estimates through successive truncation of recent data. Consistent trends in biomass and fishing mortality across retrospective fits indicate robustness of the model and reliability of its management advice.

The calculation of the percentage of the fishing reduction = $(1 - (1/(F_{ratio}))) * 100$.

As:

Fratio: $F_{current}/F_{MSY}$

F: fishing mortality (year⁻¹).

F_{MSY}: maximum sustainable fishing level.

3. Results

The analysis of the trends in catches and fishing effort, with biomass indices for the available time series, highlights a negative correlation between catch levels and biomass, supporting the hypothesis that increased fishing pressure, reflected by the growing number of vessels and catches, has progressively reduced stock abundance, with signs of slight stabilization in recent years (figure 2).

The biomass index shows an overall declining trend since 2010, with a strong interannual variability. This pattern suggests a potential reduction in the spawning stock, possibly linked to excessive fishing pressure.

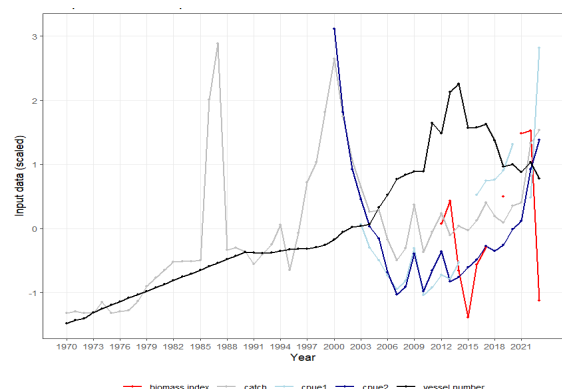


Figure 2. Available time series data related to deep-sea pink shrimp from 1970 to 2023 in GSA04.

Among the four scenarios tested (Figure 3), only the fourth one produced a reliable model fit (scenario 4). The first scenario did not converge, whereas the second and the third showed uncertainty levels too high to be acceptable.

The absence of convergence observed in scenario 1 suggests inconsistencies between historical catch records and recent biomass trend data.

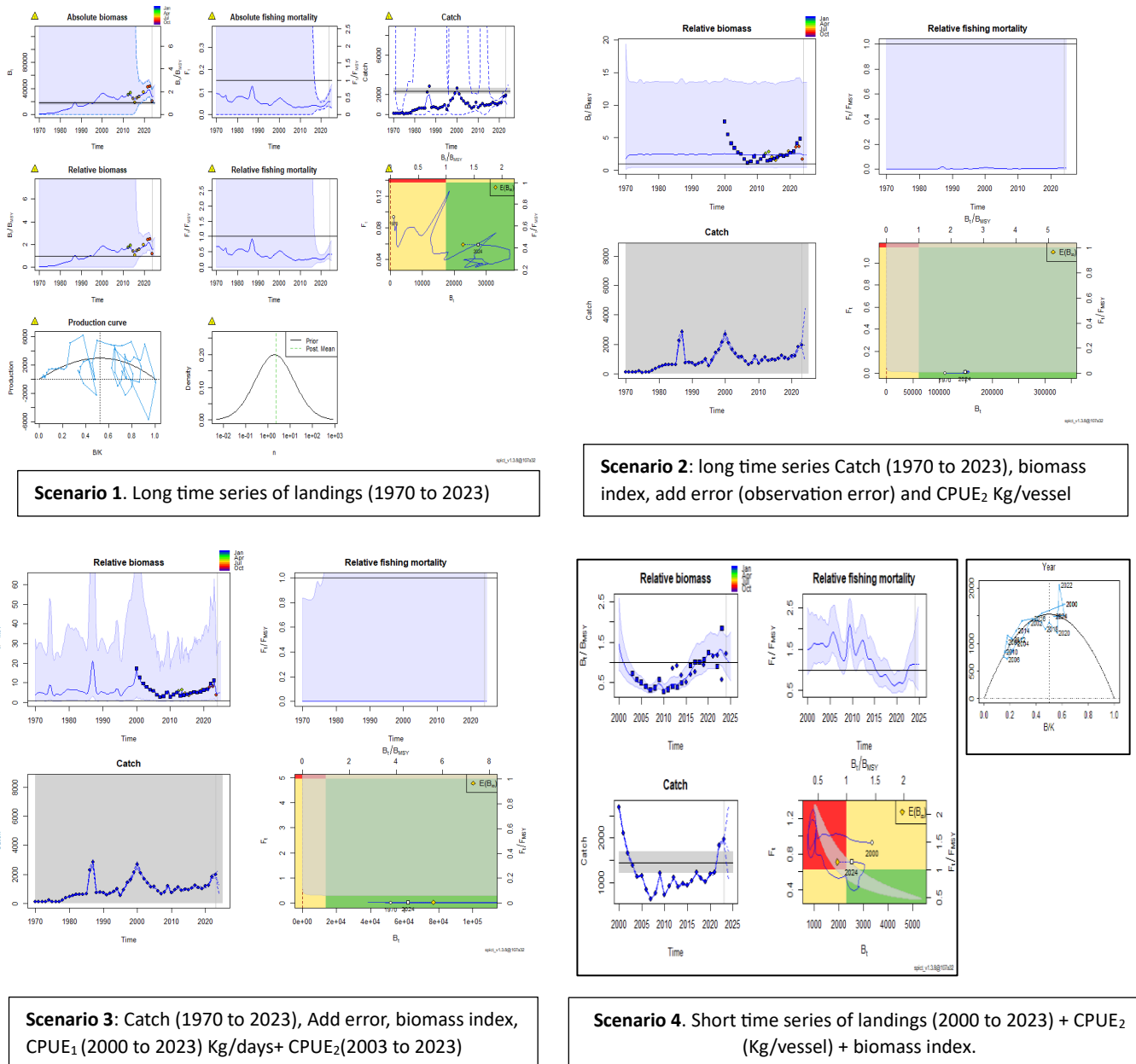


Figure 3. Output of the scenarios tested in SPiCT.

• Model Performance

Once the model converges with the scenario 4, the diagnostics of residuals and process error are done (Figure 4). The Robustness analysis is tested first by the retrospective analysis (Figure 5) and by the hindcast cross validation. The retrospective shows consistent patterns in the estimation of fishing mortality and biomass. The Mean Absolute Scaled Error (MASE) is 0.734 for the index1 and 0.971 for the second index. when MASE is higher than one, that means that the model gave strong prediction skills (Figure 6), while the sensitivity analysis indicates consistent performance of the model.

• Model Diagnostics Interpretation

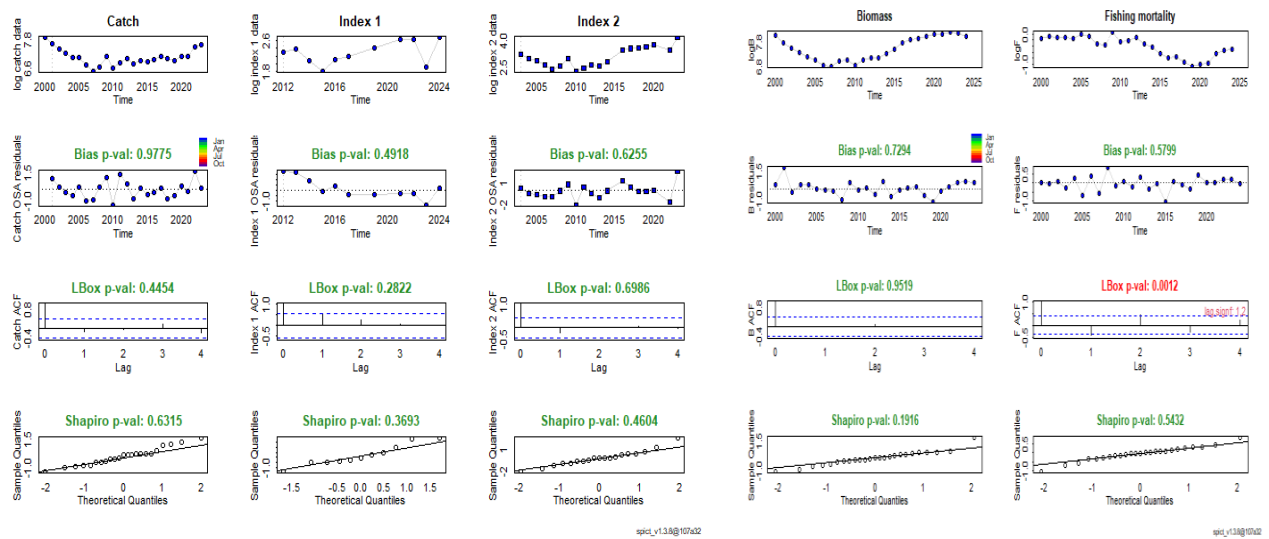


Figure 4. Diagnostics of residuals and process error.

The diagnostic plots from the SPiCT model show a generally good fit between the observed and predicted values for catches, biomass, and the two indices (CPUE₁ and Biomass index).

Bias p-values for all components (catch, indices, biomass, and fishing mortality) are above 0.05, suggesting no significant systematic bias in the residuals. Even, the Shapiro p-values are all higher than 0.05, supporting the assumption that residuals are approximately normally distributed.

All LBox p-values are above 0.05 except for

fishing mortality ($p = 0.0012$), which indicates a slight autocorrelation in its

residuals. This may reflect some temporal structure or model misspecification in the estimation of fishing mortality.

Overall, the diagnostics indicate that the model performs well and provides a reliable representation of the stock dynamics, although the slight autocorrelation in fishing mortality residuals suggests that this component should be interpreted with caution.

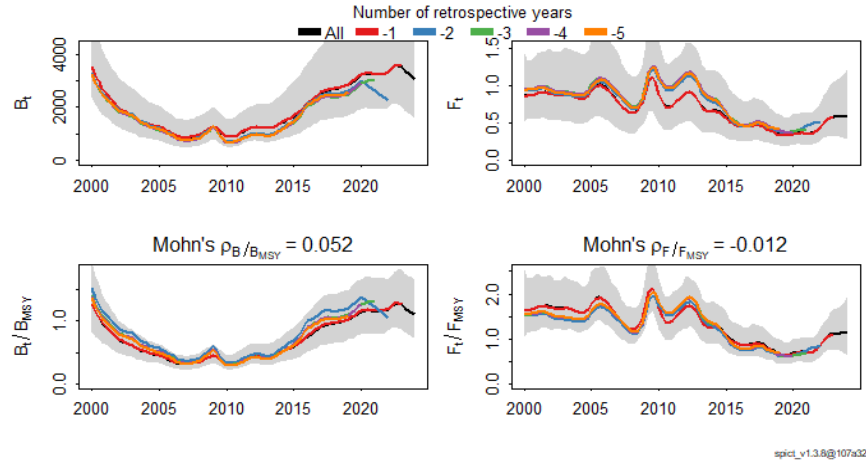


Figure 5. Retrospective analysis of the SPiCT model run for *P. longirostris* in GSA04.

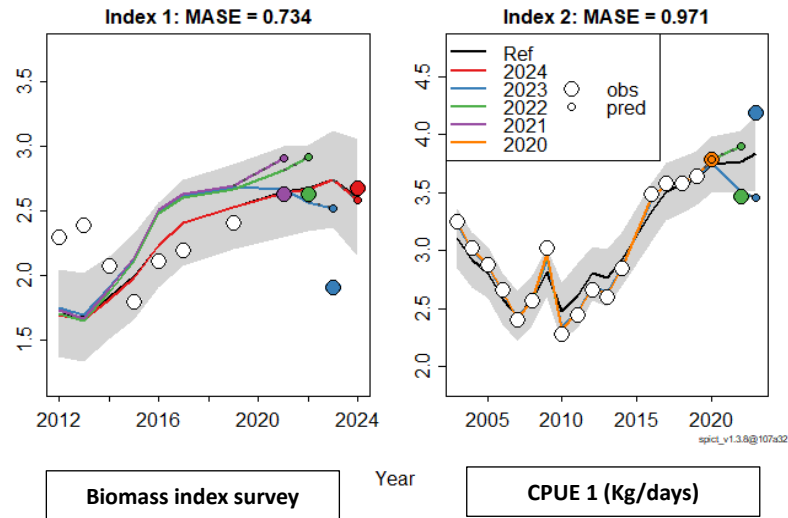


Figure 6. Hindcast cross-validation of the SPiCT model.

The results, presented in Figure 7, indicate that the stock is sustainably exploited, with biomass levels remaining above B_{MSY} ($B/B_{MSY}=1.13$). From a biomass perspective, the stock remains above B_{MSY} ; however, a declining trend is observed, possibly reflecting increased fishing pressure or changes in recruitment.

The fishing mortality level is higher than F_{MSY} ($F/F_{MSY}=1.12$). If catches and fishing effort continue to increase, the stock risks becoming overexploited. Therefore, reducing fishing mortality is recommended to ensure the sustainability of the stock. The reduction in fishing effort required to reach F_{MSY} , based on the current fishing effort, is estimated at 10.94%.

The different reference points are mentioned in the table 1.

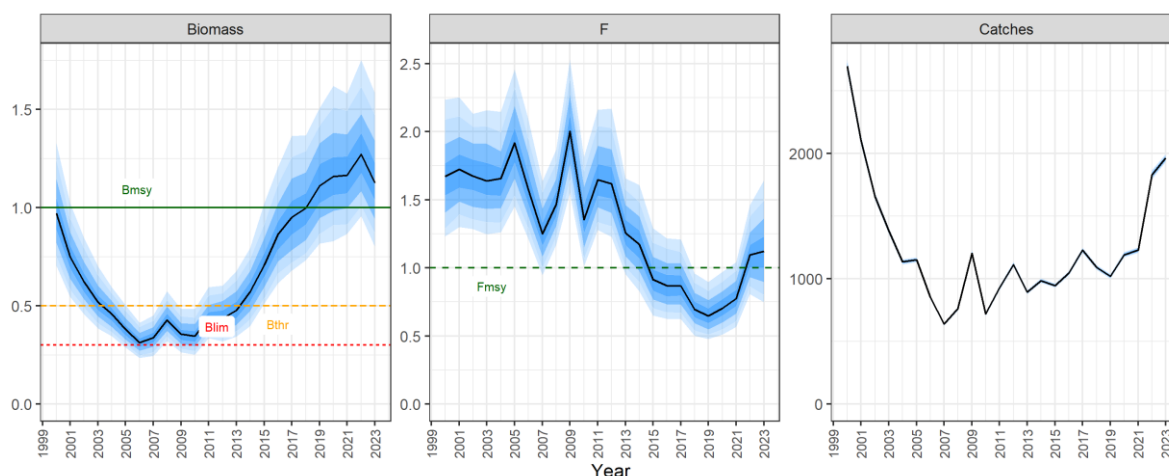


Figure 7. Deep water pink shrimp (*Parapenaeus longirostris*) in GSAs 04. Summary of assessment results, showing the estimated stock trajectories for biomass, fishing mortality (F) and total catches relative to the reference points. Darker and lighter blue shaded areas illustrated the 80% and 90% Confidence Intervals.

Table 1. Reference points from actual assessment of Deep-Sea pink shrimp stock (reference year 2023).

Current Levels	Reference Points	Quantitative Status	%F reduction
$F_{\text{current}} = 0.59$	$F_{\text{MSY}} = 0.529$	$F/F_{\text{MSY}} = 1.12$	10.94
$B_{\text{current}} = 3153.67 \text{ (t)}$	$B_{\text{MSY}} = 2801.064 \text{ (t)}$	$B/B_{\text{MSY}} = 1.13$	
	$B_{\text{LIM}} = 840.319 \text{ (t)}$		

Conclusion

The deep-sea pink shrimp shows long-term variations in catches and abundance, which may be related to its exploitation pattern as well as to its biological cycle.

While knowledge of its biology is essential, effective control of the exploitation pattern and rational management are key to ensuring the long-term sustainability of the resource.

The SPiCT model was applied using time-series data on catches and fishing effort

spanning from 1970 to 2023. However, the model achieved convergence only when a shorter time series was used, likely due to incomplete information on effort for the same period as the catch data. The assessment was validated by the GFCM working group for advice provision on a quantitative basis, considering the model's sensitivity to priors and the consistency of the retrospective and hindcast diagnostics.

Unfortunately, the SPiCT model indicates that the stock status of *Parapenaeus*

longirostris in GSA 04 is borderline between sustainable exploitation and overexploitation. Biomass is above the reference point, while fishing mortality is slightly higher than F_{MSY} .

The preservation of stock biomass requires careful management of fishing effort, ensuring that catches remain within biologically sustainable limits and it is recommended to reduce the fishing mortality by 10.94% to ensure the sustainability of the stock.

Pedersen, M.W. and C. W. Berg., 2017. A stochastic surplus production model in continuous time. *Fish and Fisheries*, 18: 226-243.

Pedersen M.W., Kokkalis A., Tobias K. Mildenberger, and Berg C.W., 2023. Handbook for the Stochastic Production model in Continuous Time (SPiCT).

Références

Ainouche N., 2009. Ecologie, biologie et exploitation de la crevette *Parapenaeus longirostris* (Lucas, 1846) de la région algéroise. Magister thesis FSB/USTHB. 84p.

Ainouche N and Nouar A., 2023. Ecobiologie et exploitation de la crevette *Parapenaeus longirostris*: bassin méditerranéen occidental. European university edition. 104 pages.

Bertrand JA, Gil de Sola L, Papaconstantinou C, Relini G, Souplet A., 2002. The general specifications of the MEDITS surveys. *Sci. mar.* 66(S2):9-17.

Froese R. and Pauly D., 2025. *SeaLifeBase*. Accessed November 9, 2025.

Kimoto A., Ortiz M., and Taylor N.G., 2023. Review of stochastic surplus production model in continuous time SPiCT methodology for the ICCAT software catalogue. *Collect. Vol. Sci. Pap. ICCAT*, 80(6): 80-84 (2023).

MEDITS., 2017. MEDITS-Handbook. Version n. 9, MEDITS Working Group: 106 pp.

Nouar A., 1985. Contribution à l'étude de la crevette Pénéide *Parapenaeus longirostris*

(Lucas, 1846) dans la région d'Alger : Ecologie-Biologie et Exploitation. Magister thesis in oceanography. Option: fishery. FSB /U.S.T.H.B. 132P.