REVIEW OF STOCHASTIC SURPLUS PRODUCTION MODEL IN CONTINUOUS TIME (SPiCT) METHODOLOGY FOR THE ICCAT SOFTWARE CATALOGUE

A. Kimoto[1], M. Ortiz[1], and N.G Taylor[1]

SUMMARY

The SCRS in 2022 recommended that the SPiCT model (Stochastic surplus production model in continuous time) will be considered for inclusion in the ICCAT software catalogue in 2023. SPiCT by Pedersen and Berg (2017) incorporates dynamics in both biomass and fisheries and observation error of both catches and biomass indices and based on the generalized surplus production model. The model has a general state-space form that can contain process and observation-error as well as state-space models that assume error-free catches. This method has been widely applied to the ICES (International Council for the Exploration of the Sea) stocks as well as international migratory species. The Guideline for SPiCT provides a checklist for the acceptance of a SPiCT assessment by ICES, the R-package of SPiCT and ShinyApp are available with the Handbook as a user guide in github. The authors fully recommend the ICCAT to register this SPiCT methodology in the ICCAT software catalogue.

RÉSUMÉ

Le SCRS a recommandé en 2022 que le modèle SPiCT (modèle stochastique de production excédentaire en temps continu) soit inclus dans le catalogue de logiciels de l'ICCAT en 2023. Le SPiCT de Pedersen et Berg (2017) incorpore la dynamique à la fois de la biomasse et des pêcheries ainsi que l'erreur d'observation des captures et des indices de biomasse, et il est basé sur le modèle généralisé de production excédentaire. Le modèle a une forme générale état-espace qui peut contenir des erreurs de processus et d'observation ainsi que des modèles état-espace qui postulent des captures sans erreur. Cette méthode a été largement appliquée aux stocks du CIEM (Conseil international pour l'exploration de la mer) ainsi qu'aux espèces migratrices internationales. Les lignes directrices du SPiCT fournissent une liste de contrôle pour l'acceptation d'une évaluation SPiCT par le CIEM. Le paquet R de SPiCT et l'application Shiny sont disponibles ainsi que le manuel en tant que guide d'utilisation dans Github. Les auteurs recommandent vivement à l'ICCAT d'inclure cette méthodologie SPiCT dans le catalogue de logiciels de l'ICCAT.

RESUMEN

El SCRS recomendó en 2022 que el modelo SPiCT (modelo estocástico de producción excedente en tiempo continuo) se considerara para su inclusión en el catálogo de software de ICCAT en 2023. SPiCT de Pedersen y Berg (2017) incorpora la dinámica tanto de la biomasa como de las pesquerías y el error de observación tanto de las capturas como de los índices de biomasa y se basa en el modelo de producción excedente generalizado. El modelo tiene una forma general estado-espacio que puede contener errores de proceso y de observación, así como modelos estado-espacio que parten del supuesto de capturas sin errores. Este método se ha aplicado ampliamente a los stocks de ICES (Consejo Internacional para la exploración del mar), así como a las especies migratorias internacionales. La Guía para SPiCT proporciona una lista de comprobación para la aceptación de una evaluación SPiCT por parte de ICES, el paquete R de SPiCT y ShinyApp están disponibles con el Manual como guía de usuario en github. Los autores recomiendan plenamente a ICCAT que registre esta metodología SPiCT en el catálogo de software de ICCAT.

KEYWORDS

ICCAT Software Catalogue, ShinyApp, SPiCT, R-package

[1] ICCAT Secretariat. ai.kimoto@iccat.int

Introduction

The SCRS in 2022 recommended that the SPiCT model (Stochastic surplus production model in continuous time) will be considered for inclusion in the ICCAT software catalogue in 2023 (Anon., 2023). Following this recommendation, this document provides a review of the SPiCT for the ICCAT software catalogue in 2023.

SPiCT model

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) generalized surplus production model. The model has a general state-space form that can contain process and observation-error as well as state-space models that assume error-free catches. 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).

Benefits of the continuous-time state-space model formulation include the ability to provide estimates of exploitable biomass and fishing mortality at any point in time from data sampled at arbitrary and possibly irregular intervals (Coelho et al., 2019). It is modified to include stochastic process noise terms. SPiCT models thus requires catch and abundance indices.

The ICES (International Council for the Exploration of the Sea) introduced SPiCT well and includes it as Category 2 (ICES, 2023a). Often surplus production models have been classified as data-limited methods, like the ICES used to classify, and there is no globally accepted definition of "data-limited". However, the ICES recently in 2022 updated their advice on fishing opportunities which includes their classifications of stocks. The Category 2 includes stocks with analytical assessments and forecasts that are only treated qualitatively as well as stocks with surplus production models, e.g. *SPiCT, JABBA, without an MSE*; includes stocks with quantitative assessments and forecasts which, for a variety of reasons, are considered indicative of trends in fishing mortality, recruitment, and biomass. Like the other regions or organizations, the authors consider SPiCT as data-moderate model.

Application to fisheries stocks

This model currently has been increasingly applied to various stocks for their assessments and Operating Models since 2018 after their publication (Pedersen and Berg, 2017). Especially the ICES Community has used it for their Category 3 (ICES, 2021a) stocks that was updated recently to Category 2 stocks in ICES (2022). For example, North Sea skates by Fischer et al. (2018), brill in Subarea 4 and divisions 3.a and 7.d–e by ICES (2019), nephrops in Cantabrian Sea by González-Herraiz (2020) and pollack in ICES subarea 8 and division 9a by Sampedro (2021).

They also have been currently considered to provide MSY advice for selected 9 stocks by WKBMSYSPiCT (Benchmark workshop on development of MSY advice using SPiCT) (ICES, 2023b), built upon the first WKBMSYSPiCT meeting (ICES. 2021b).

The use of SPiCT in the other RFMOs (Regional Fisheries Management Organizations) has become gradually common. In the Atlantic Ocean, there are several attempts for the ICCAT stocks to provide the SPiCT analyses in recent years for the North Atlantic shortfin mako shark (Maguire and Berg 2020), the North Atlantic swordfish stock (Ortiz and Kimoto, 2022), and the northeastern Atlantic porbeagle (Ortiz et al., 2022). In the Pacific, Pacific saury (Kulik 2017) in the NPFC (North Pacific Fisheries Commission), South Pacific Albacore (Scott et al., 2022) in the WCPFC (Western and Central Pacific Fisheries Commission).

There are also some publications comparing SPiCT to the other data-limited methods. Bouch (2021) applied Catch-MSY (CMSY) model and SPiCT to 17 data-rich stocks that the ICES accepted age-based assessments. They compared the stock status estimates (F/F_{MSY} and B/B_{MSY}) among models. Cousido-Rocha et al. (2022) studied the advantages and disadvantages of each of the three surplus production models (CMSY, SPiCT, and JABBA) through detail formulations, main features, and characteristics of the available software.

Software developments

The ICES has discussed and reviewed this methodology well, and organized manuals, software, and website.

- **SPiCT R-Package and ShinyApp**
  SPiCT R-package developed by Pedersen, Kokkalis, Mildenberger, and Berg
  This site is the most important for the ICCAT software catalogue.
  https://github.com/DTUAqua/spict (github)
  https://ices-tools-prod.r-universe.dev/spict

  An R-package for fitting surplus production models in continuous-time to fisheries catch data and biomass indices (either scientific or commercial). Main advantages of SPiCT are: 1) All estimated reference points (MSY, Fmsy, Bmsy) are reported with uncertainties, 2) The model can be used for short-term forecasting and management strategy evaluation, 3) The model is fully stochastic in that observation error is included in catch and index observations, and 4) process error is included in fishing and stock dynamics. The model is formulated in continuous-time and can therefore incorporate arbitrarily sampled data.

  PandoraShinyApp developed by Mantopoulou-Palouka, Kikeri, Sgardeli, and Damalas
  This site is useful to apply the model via ShinyApp.
  https://github.com/PandoraShinyApp/StockAssessmentApps (github)
  https://cloudfs.hcmr.gr/index.php/s/yRqWk0zTTOCWbZT (owncloud)

  https://www.ices.dk/PANDORA/Pages/assessment.aspx
  The SPiCT application (PandoraShinyApp) in PANDORA's Toolbox includes the two time-variant productivity extensions, allowing for gradually varying productivity or regimes of productivity (Mildenberger et al., 2020)

  PANDORA (Paradigm for Novel Dynamic Oceanic Resource Assessments) is a cooperation of 25 project partners from across Europe, covering all marine waters of the EU and Norway (PANDORA, 2023). PANDORA addresses important, practical, and region-specific research gaps for European fisheries, and provides new biological knowledge on fish and their ecosystems. One of their projects provides PANDORA's Toolbox and includes the SPiCT application that the user can implement fisheries stock assessment models/approaches.

- **SPiCT Guideline, Handbook, Manual and Source code**
  Guideline By Mildenberger et al., 2022
  https://raw.githubusercontent.com/DTUAqua/spict/master/spict/inst/doc/spict_guidelines.pdf

  This is a living document, be sure to check for the latest update (in github). The SPiCT package is actively developed, check for the most recent package version and report problems at their github site. This document provides Checklist for the acceptance of a SPiCT assessment ICES category 3 stocks can be managed using the official advice rule 3.1.1 and 3.1.2 in ICES (2017), which requires an accepted SPiCT assessment.

  Handbook for SPiCT R-package by Pedersen et al., 2022
  https://github.com/DTUAqua/spict/raw/master/spict/inst/doc/spict_handbook.pdf
  This document is helpful handbook how to run the R-package of SPiCT.

Conclusions

The authors fully recommend the ICCAT to register this SPiCT methodology in the ICCAT software catalogue.

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