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Incorporating a creep factor into the Chile Jack Mackerel CPUE index standardization

Chile

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Abstract

The central-southern fleet for the jack mackerel fishery in Chile has experienced technological changes over time, which may not be reflected by other variables already considered in the CPUE abundance index. In this study, we explore different approaches to estimate and include a creep correction factor into the standardization of the Chile CPUE index. From the survey of the JM fishery conducted during 2023, we used fisher's responses to determine the magnitude of perceived changes in fleet efficiency and periods of occurrence to estimate a creep factor. Next, we implemented a GLM, where the inclusion of a creep factor as a dummy variable in the standardization model of the Chile CPUE index showed multicollinearity and aliasing that prevented its use as an additional factor in the model. However, when using the corrected CPUE index by an informed creep factor as the response variable in a GLM, the model exhibited a similar pattern as with the uncorrected CPUE. We discuss the benefits and limitations of this approach, and propose next steps for adjusting and improving its reliability. Next steps, may include an additional survey to collect complementary user data that can improve the robustness of the index standardization process.

Background

The central-southern fleet for the jack mackerel fishery in Chile has experienced technological changes over time, which may not be reflected by other variables already considered in the CPUE standardization process. To account for these changes, during the Jack Mackerel Benchmark Workshop in 2022, the SPRFMO Scientific Committee agreed to apply a factor of 1% per year to correct the CPUE abundance indexes of Jack Mackerel for the Chilean and Peruvian fleets. However, there are concerns over the technical implications of a fixed rate, and the exploration of alternative efficiency correction factors was recommended. The impact of effort creep is likely to be minimal over the short term, but could grow more pronounced over time, and additional steps would be required in order to provide a more long-term solution to this problem. Recently, there have been efforts to estimate both the impact of alternative creep correction factors (Hintzen 2023, Zenteno & Payá 2023).

In this study we explore different approaches to estimate and include a creep correction factor into the standardization of the Chile CPUE index. We discuss the benefits and limitations of this approach, and propose next steps for adjusting and improving its reliability.

Objective

- Analyze different approaches to include the developed survey efficiency factor in the correction of the abundance index based on the CPUE of the central-south zone.
- Assess the statistical viability and applicability of including this efficiency factor in the standardization process of the Chile CPUE index.

Methods

During the survey of efficiency changes of the JM fishery, users were asked specifically to quantify the reduction of effort to locate jack mackerel aggregations associated with the use of technological advances and tools, and the period of ocurrence of these improvements in fishing operations. These responses were included in the standardization model of the CPUE index, first as a dummy variable and, since the magnitude of the change in efficiency would prevent a posterior index correction. On a previous analysis, we considered alternative survey responses to construct the creep correction factor (Zenteno & Payá 2023). After a review was conducted, we identified potential limitations associated with the way some of the survey questions were designed. In this sense, the responses incorporated in the efficiency factor in this study address the issues identified.

Survey responses from fishers were used to determine the magnitude of perceived changes in fleet efficiency over two dimensions. First, responses were used to determine the size of the effect of technological changes in the fishing activity, namely the introduction of multibeam sonars and the delivery of oceanographic satellite information to fishing vessels. Second, we used responses to establish the period were these techonological improvements were implemented. According to this approach, we were able to design a criteria table, which was used to correct the CPUE data series, to all fishing trips of the fleet were data was available (**Table 1**).

Previous to including the creep factor as a dummy variable into the GLM used in the index standardization process, we checked potential interdependence and correlation of the efficiency correction factor, by conducting multicollinearity and linear dependence analyzes with the other variables used in the base standardization process.

Finally, we tested an alternative approach to correct the changes in efficiency in the fleet over time, as estimated by the users survey. Instead of including as a dummy variable, we implemented a GLM parallel to the one used to standardize the CPUE abundance index (**Table 1**), were we defined a CPUE corrected by the effort creep factor as the response variable, according to:

$$\log(CPUE_{creep}) = \beta_1 \cdot yearf + \beta_2 \cdot quarter + \beta_3 \cdot zone + \beta_4 \cdot hc$$

Where $CPUE_creep$ is the creep-corrected index, yearf is the year as a factor, quarter is the quarter as a factor, zone corresponds to fishing zone as a factor and hc is the vessel haul capacity. This GLM is designed with the same explanatory variables as with the GLM used in the current CPUE standardization process.

Table 1: Correction criteria for the CPUE data series of the central-southern fleet, as obtained by the fisher survey conducted during July 2023. The correction multiplier was applied to each CPUE data point, according to the criteria of each corresponding period. The survey creep factor was obtained as the mean of perceived reduction in searching time (from a maximum of 1) of jack mackerel aggregations during fishing trips.

Period	Survey creep factor (sd)	Correction multiplier (sd)
1983-2004	0	1
2005-2024	0.383(0.207)	0.616

Results

The inclusion of a creep factor as a dummy variable in the standardization model of the Chile CPUE index showed multicollinearity and aliasing that prevented its use as an additional factor. However, when using the corrected CPUE index by an informed creep factor as the response variable in a GLM, the model exhibited a similar pattern as with the uncorrected CPUE (AIC = -31291) (**Tabla 2**)).

Table 2: Summary of the GLM Model

term	estimate	std.error	statistic	p.value
yearf1983	-0.1700816	0.0158448	-10.734195	0.0000000
yearf1984	-0.2510643	0.0162830	-15.418832	0.0000000
yearf1985	-0.3685420	0.0158130	-23.306198	0.0000000
yearf1986	-0.5420650	0.0153306	-35.358383	0.0000000
yearf1987	-0.3645745	0.0154212	-23.641086	0.0000000
yearf1988	-0.4842921	0.0155336	-31.177159	0.0000000
yearf1989	-0.4989571	0.0155621	-32.062255	0.0000000
yearf1990	-0.6500104	0.0147351	-44.112921	0.0000000
yearf1991	-0.5278670	0.0150618	-35.046657	0.0000000
yearf1992	-0.5874891	0.0156189	-37.613931	0.0000000
yearf1993	-0.7027035	0.0158270	-44.398905	0.0000000
yearf1994	-0.6180762	0.0156438	-39.509344	0.0000000
yearf1995	-0.7195877	0.0149427	-48.156629	0.0000000
yearf1996	-0.7193716	0.0170083	-42.295336	0.0000000
yearf1997	-0.9138787	0.0167370	-54.602455	0.0000000
yearf1998	-1.0739032	0.0202648	-52.993578	0.0000000
yearf1999	-1.0502969	0.0232556	-45.163181	0.0000000
yearf2000	-1.0726680	0.0233792	-45.881231	0.0000000
yearf2001	-0.8790482	0.0235114	-37.388145	0.0000000
yearf2002	-1.0020577	0.0255713	-39.186800	0.0000000
yearf2003	-1.1303305	0.0255848	-44.179721	0.0000000
yearf2004	-1.0531511	0.0259410	-40.597952	0.0000000
yearf2005	-1.6248368	0.0275278	-59.025225	0.0000000
yearf2006	-1.5002716	0.0288324	-52.034149	0.0000000
yearf2007	-1.8161787	0.0291210	-62.366655	0.0000000
yearf2008	-2.1729371	0.0380123	-57.164085	0.0000000
yearf2009	-2.3571581	0.0350040	-67.339618	0.0000000
yearf2010	-2.6360033	0.0527470	-49.974484	0.0000000
yearf2011	-3.2195343	0.0474787	-67.810139	0.0000000
yearf2012	-2.1042416	0.0448492	-46.918171	0.0000000
yearf2013	-2.2251621	0.0461042	-48.263717	0.0000000
yearf2014	-2.4480765	0.0440494	-55.575689	0.0000000
yearf2015	-2.6373741	0.0660151	-39.951093	0.0000000
yearf2016	-2.0374967	0.0414558	-49.148655	0.0000000
yearf2017	-1.8553592	0.0413719	-44.845828	0.0000000

yearf2018	-2.2847130	0.0303223	-75.347520	0.0000000
yearf2019	-1.7411293	0.0351990	-49.465291	0.0000000
yearf2020	-1.4653262	0.0381616	-38.397916	0.0000000
yearf2021	-1.3830115	0.0367206	-37.663117	0.0000000
yearf2022	-1.3549336	0.0332474	-40.753071	0.0000000
yearf2023	-1.3980366	0.0304566	-45.902628	0.0000000
yearf2024	-1.3844226	0.0324914	-42.608944	0.0000000
quarter2	0.0982730	0.0060913	16.133396	0.0000000
quarter3	-0.0750018	0.0067659	-11.085216	0.0000000
quarter4	-0.3834646	0.0079269	-48.374963	0.0000000
zoneZ12	-0.0900803	0.0219115	-4.111105	0.0000394
zoneZ13	-0.3378330	0.0381718	-8.850322	0.0000000
zoneZ21	-0.0369779	0.0100539	-3.677969	0.0002352
zoneZ22	-0.0776561	0.0160735	-4.831301	0.0000014
zoneZ23	-0.2530776	0.0259135	-9.766253	0.0000000
zoneZ31	-0.3157484	0.0121203	-26.051138	0.0000000
zoneZ32	-0.3124254	0.0239061	-13.068829	0.0000000
zoneZ33	-0.3485721	0.0270897	-12.867337	0.0000000
hchc2	-0.0635215	0.0098252	-6.465142	0.0000000
hchc3	-0.0660891	0.0103684	-6.374112	0.0000000
hchc4	-0.2184174	0.0134462	-16.243854	0.0000000
hchc5	-0.2621193	0.0111326	-23.545187	0.0000000
hchc6	-0.3663738	0.0151231	-24.226097	0.0000000
hchc7	-0.3775911	0.0167229	-22.579311	0.0000000
hchc8	-0.3277536	0.0134167	-24.428719	0.0000000
hchc9	-0.4575952	0.0136659	-33.484387	0.0000000
hchc10	-0.5354194	0.0156503	-34.211492	0.0000000

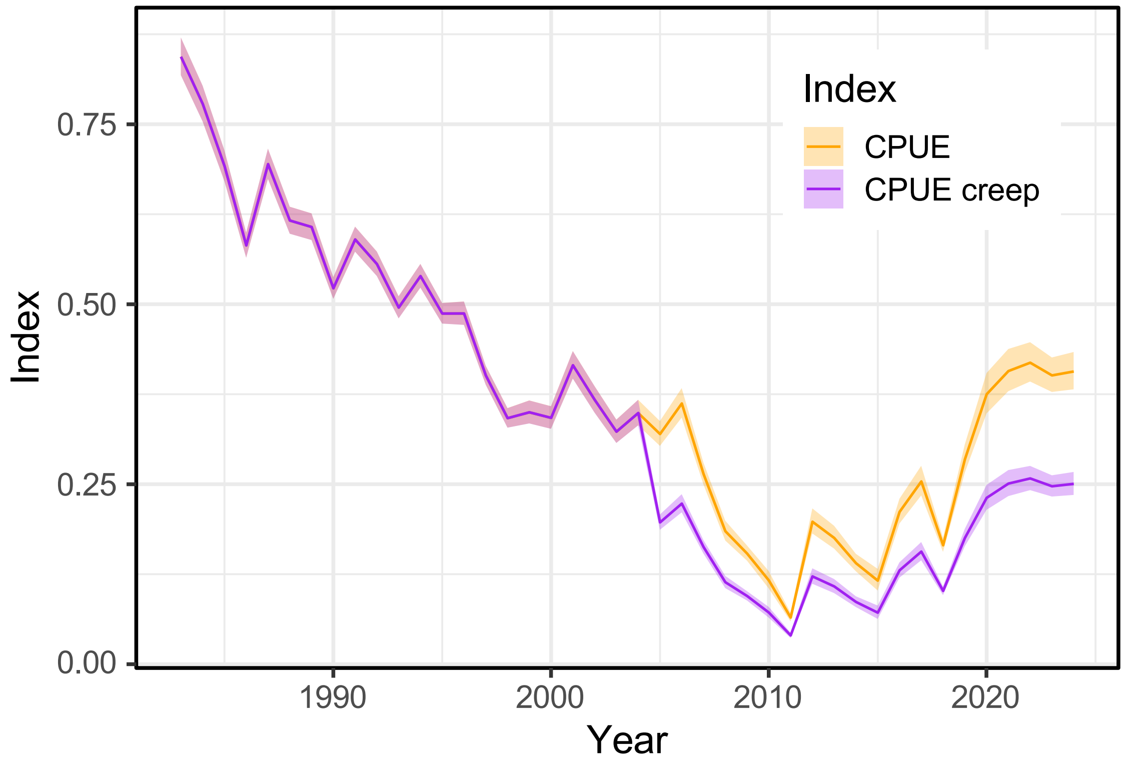

Figure 1: Predicted abundance (CPUE) index of Chilean jack mackerel (*Trachurus murphyi*) fishery of central-southern Chile, for the base GLM model and the creep-corrected CPUE as response variable. Shaded lower and upper limits represent the standard deviation of the series.

Discussion

An analysis was made to explore the potential use of a creep factor to be used in the standardization process of the CPUE index of the Chile fleet. When adding technological changes as a dummy variable, the analysis exhibited multicollinearity between the creep factor and other variables used in the CPUE index standardization, which prevented us from applying the creep factor. However, when using the corrected CPUE as the response variable in the glm instead, the model provides an standardized CPUE index that, which can be used to compare with the base index. Nevertheless, it is recommended that the survey approach is reassessed in order to collect complementary user data that can improve the robustness in the index standardization process.

References

Zenteno, J. I., & Payá, I. (2023). *Effort creep in the Jack Mackerel central-southern fleet in Chile: Preliminary analysis and proposed alternative*. Working document presented at the 12th Scientific Committee Meeting of the South Pacific Regional Fisheries Management Organisation (SPRFMO), Ciudad de Panamá, Panama. Available online.