Fisheries New Zealand
Tini a Tangaroa

Stock hypotheses for ling in the Sub-Antarctic (LIN 5&6 and LIN 6B)

New Zealand Fisheries Assessment Report 2024/83

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PLAIN LANGUAGE SUMMARY

Ling (*Genypterus blacodes*) is an important commercial fish species in New Zealand middle depths waters and is caught mainly by bottom trawls, bottom longlines, and increasingly by potting.

This report investigates various stock hypotheses for in the Sub-Antarctic ling. Differences in growth suggested that LIN 3&4, LIN 5&6, and LIN 7WC were likely to be different stocks and that the current boundaries between those stocks were likely to be adequate. Catch rates, age structure, and growth data suggested that LIN 6B was unlikely to be part of LIN 3&4, with weak evidence that it was part of LIN 5&6.

Because of the paucity of data available to assess LIN 6B as a separate stock, and the similarities in the information between LIN 5&6 and LIN 6B, the Fisheries New Zealand Deepwater Working Group decided to include LIN 6B with LIN 5&6 as a single Sub-Antarctic ling stock (LIN 5&6 and LIN 6B) for the 2024 stock assessment of Sub-Antarctic ling.

EXECUTIVE SUMMARY

Mormede, S.[1]; Dunn, A.[2]; Webber, D.N.[3] (2024). Stock hypotheses for ling in the Sub-Antarctic (LIN 5&6 and LIN 6B).

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Ling (*Genypterus blacodes*) are an important commercial species with adults found throughout the middle depths of the New Zealand Exclusive Economic Zone (EEZ) typically in depths of 100 m to 800 m. Ling are caught mainly by deepwater trawlers, demersal longliners, and more recently by potting.

There are at least five major biological stocks of ling in New Zealand waters — the Chatham Rise, the Sub-Antarctic (including the Stewart-Snares shelf and Puysegur Bank), the Bounty Platform, the west coast of the South Island, and the Cook Strait. Ling on the Bounty Platform has historically been assessed as a separate stock from the Sub-Antarctic although a 2022 characterisation of all ling stocks suggested that ling in the Sub-Antarctic (LIN 5&6 and LIN 6B) were a single stock, with some between area seasonal movement of adult fish.

Following up on this work, the stock structure of Sub-Antarctic ling is further investigated in this report, with differences in growth suggesting that LIN 3&4, LIN 5&6, and LIN 7WC were likely to be different stocks and that the current boundaries between those stocks were likely to be adequate. Based on available catch rate, age structure, and growth information, LIN 6B was considered unlikely to be part of LIN 3&4, with weak evidence that it was part of LIN 5&6. Because of the paucity of data available to assess LIN 6B as a separate stock, and the similarities in the information between LIN 5&6 and LIN 6B, the Fisheries New Zealand Deepwater Working Group decided to include LIN 6B with LIN 5&6 as a single Sub-Antarctic ling stock (LIN 5&6 and LIN 6B).

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[2] Ocean Environmental Ltd.
[3] Quantifish Ltd.

1. INTRODUCTION

Ling (*Genypterus blacodes*) are an important commercial species with adults found throughout the middle depths of the New Zealand Exclusive Economic Zone (EEZ) typically in depths of 100 m to 800 m (Hurst et al. 2000). Ling are managed as eight administrative Quota Management Areas (QMAs, Figure 1), with five (LIN 3, 4, 5, 6, and 7) reporting about 95% of landings. Ling are caught mainly by deepwater trawlers, often as bycatch in hoki (*Macruronus novaezelandiae*) target fisheries, by demersal longliners (Mormede et al. 2021, 2022, 2023), and more recently by potting (Mormede et al. 2024a).

There are at least five major biological stocks of ling in New Zealand waters (Horn 2005)—the Chatham Rise, the Sub-Antarctic (including the Stewart-Snares shelf and Puysegur Bank), the Bounty Platform, the west coast of the South Island, and the Cook Strait. The ling biological stocks were defined using statistical areas as described in Figure 1 and Figure 2.

LIN 6B was assumed to be a distinct biological stock from the rest of the Sub-Antarctic based on the presence of at least two spawning areas and on reported differences in trace element concentrations (Horn 2005). Recent analyses have supported the hypothesis that the Sub-Antarctic area holds a single stock, but that there is some seasonal movement of adult fish, probably related to spawning (Horn 2022). Otolith morphology also supported the hypothesis of a single Sub-Antarctic stock (Ladroit et al. 2017).

As part of the 2024 characterisation of the Sub-Antarctic ling stock, further investigations into the likely stock structure of ling in that region were carried out using available biological data routinely collected and used for stock assessment purposes. These involved investigating the different data available to assess whether ling in LIN 6B was likely to be part of the LIN 5&6 stock, part of the LIN 3&4 stock, or a stand-alone stock. Furthermore, the location of the split between the LIN 3&4, LIN 5&6, and LIN 7WC was also investigated. Throughout this report, LIN 5&6 denotes the Sub-Antarctic areas of ling excluding the LIN 6B region (Figure 1).

This report summarises this investigation. It was funded as part of Fisheries New Zealand project LIN 2023-01, with the aim 'to carry out stock assessments of ling (*Genypterus blacodes*) in the Sub-Antarctic (LIN 5, 6, & 6B) including estimating biomass and stock status.' and fulfilled part of Objective 1: 'To carry out a descriptive analysis of the commercial catch and effort data for ling (LIN 5, 6, and 6B) in the Sub-Antarctic, and update the standardised catch and effort analyses.'

The outputs from this investigation were used to inform the stock assessment of ling in the Sub-Antarctic (Mormede et al. 2024 a 2024 b).

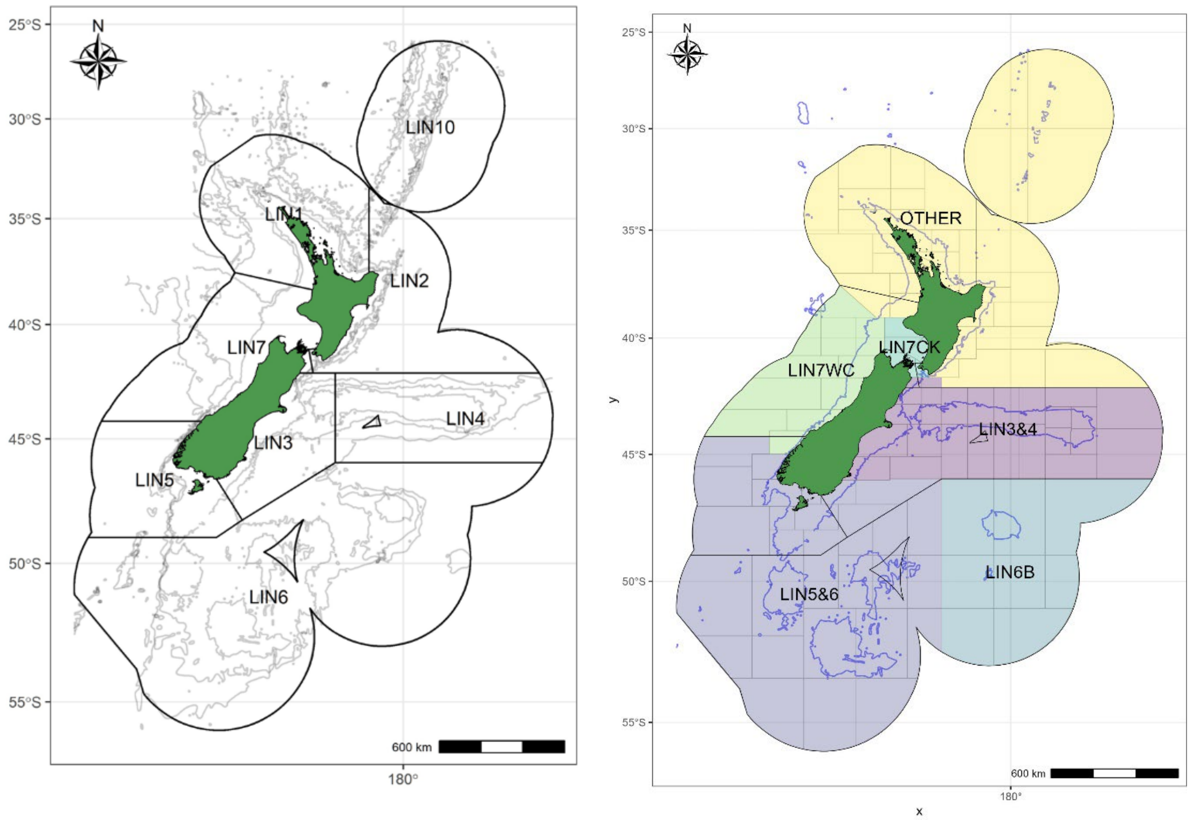

Figure 1: Quota Management Areas (QMAs, left) and biological stock boundaries (right) for ling, as used in this analysis.

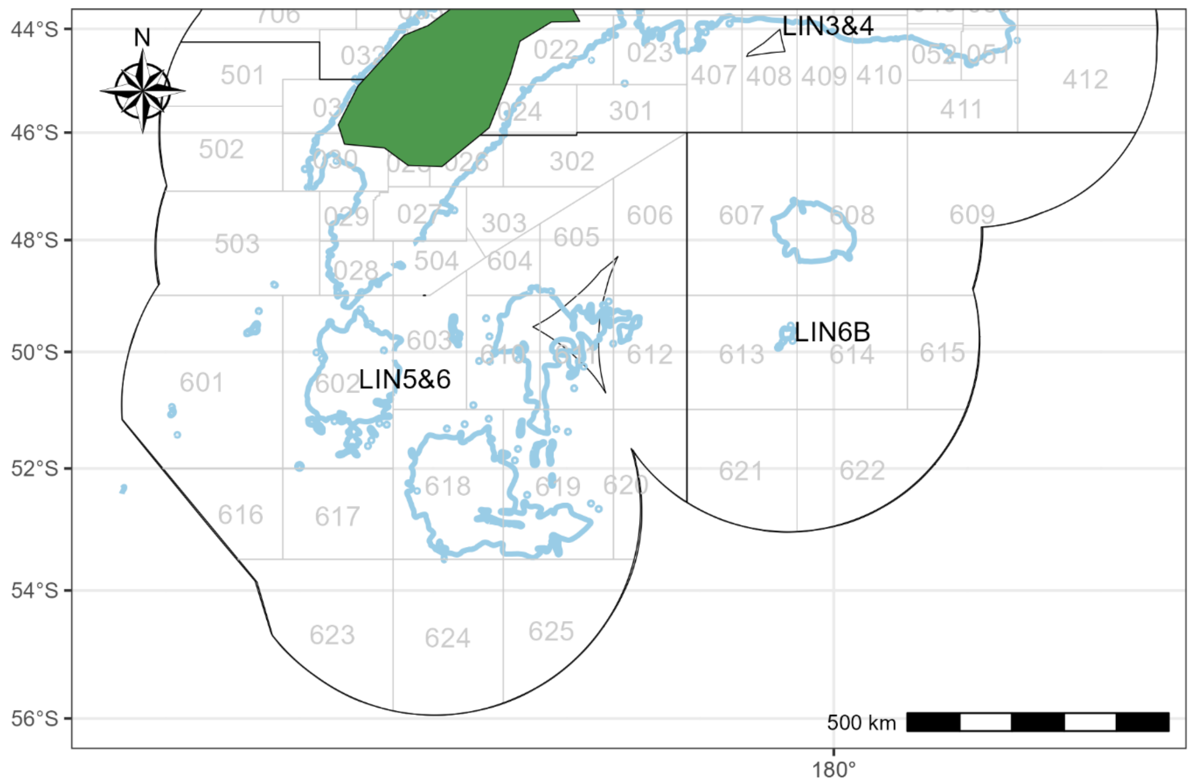

Figure 2: Biological stock boundaries and Statistical Areas for ling in the Sub-Antarctic and adjoining Statistical Areas.

2. METHODS

The data used for this analysis were the commercial catch and effort data, the observer data from observed trips that caught or targeted ling, and survey data. The data were extracted, checked and analysed as part of project LIN2023-01 (Mormede et al. 2024a). The present report summarises the information on stock structure hypotheses for Sub-Antarctic ling.

3. RESULTS

3.1 Ocean currents

Ocean currents indicate that there is likely to be minimal mixing between LIN 3&4 and LIN 6B but that LIN 5&6 and LIN 6B could potentially be a single stock, two stocks, or that LIN 6B could be an offshoot of LIN 5&6 (Figure 3).

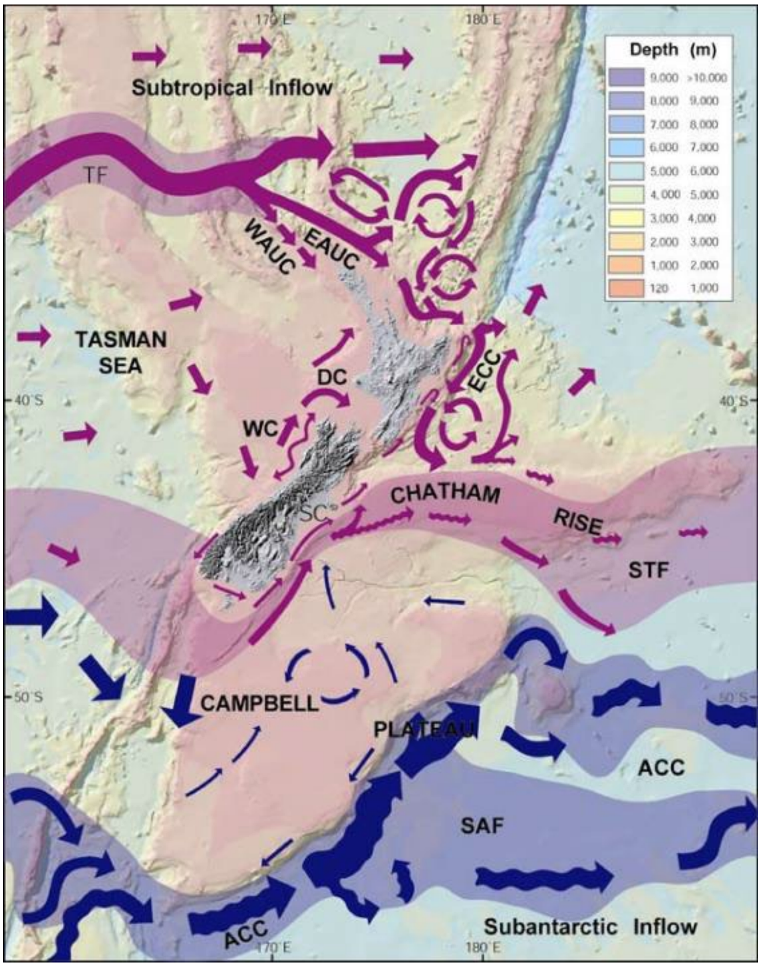

Figure 3: Ocean currents around New Zealand (Stevens & Chiswell 2024). Graphic produced by Stephen Chiswell/NIWA, used with permission.

3.2 Length data

Unscaled length frequency distributions were plotted by stock for the bottom longline ling fisheries. Results showed that ling in LIN 5&6 were smaller than in the other areas, with larger fish absent in that region. Furthermore, LIN 6B also had larger males than LIN 3&4 but similar to those in LIN 7WC and LIN 7CK (Figure 4).

A spatial tree regression analysis of ling length was attempted for the bottom trawl and longline fleets combined, for the entire New Zealand EEZ, with the spatial variable offered as 0.5º blocks. This analysis was implemented in 'R' (R Core Team 2019) using the R package *rpart*. The dependent variable in this regression was the mean length of ling per fishing event. Other parameters such as fishing method, depth, and month were offered but not included in the final model: the spatial parameter was sufficient to explain the median length per set. Results showed that LIN 5&6 was missing the larger fish, LIN 6B missing the smaller fish (but note that there is no bottom trawl fishery in this area, which would typically catch the smaller fish), whilst LIN 3&4 had the entire length range, with smaller fish present on the south side of the Chatham Rise and larger fish in the north. LIN 7WC seemed to be missing the smallest fish (Figure 5).

Integrated Nested Laplace Approximation (INLA) (Rue et al. 2009) was used to develop spatio-temporal models of fish length in the Sub-Antarctic only, using bottom longline data only. The R package *ClustGeo* was used to derive spatial fishery strata using hierarchical clustering with geographic constraints (Chavent et al. 2018). Detailed methods and results are available elsewhere (Mormede et al. 2024a). The best model included year, sex, month, depth, and space parameters. Spatial results showed that LIN 6B had larger fish than the rest of the Sub-Antarctic and that the areas close to the New Zealand continent were different from those further south (Figure 6).

Raw length data seem to indicate that LIN 6B is likely to be a different stock from LIN 5&6 and possibly from LIN 3&4 as well.

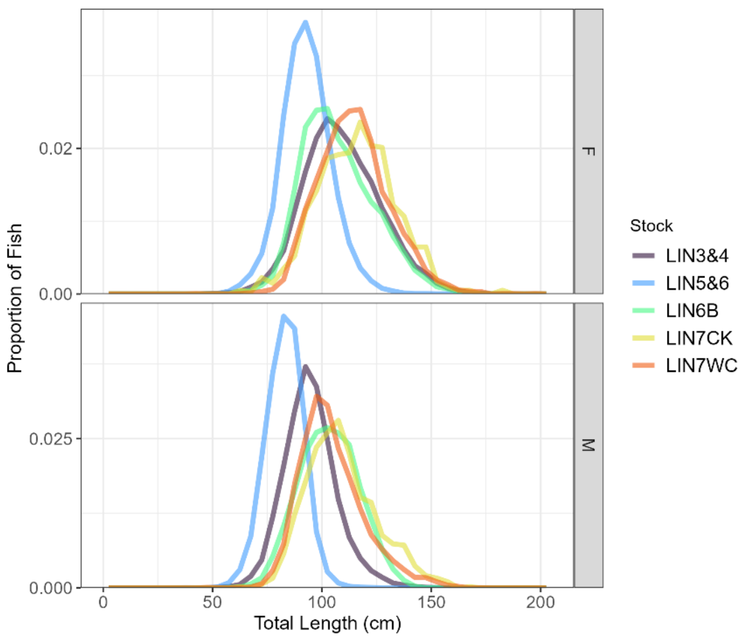

Figure 4: Unscaled length frequency distributions by stock for bottom longline ling fisheries.

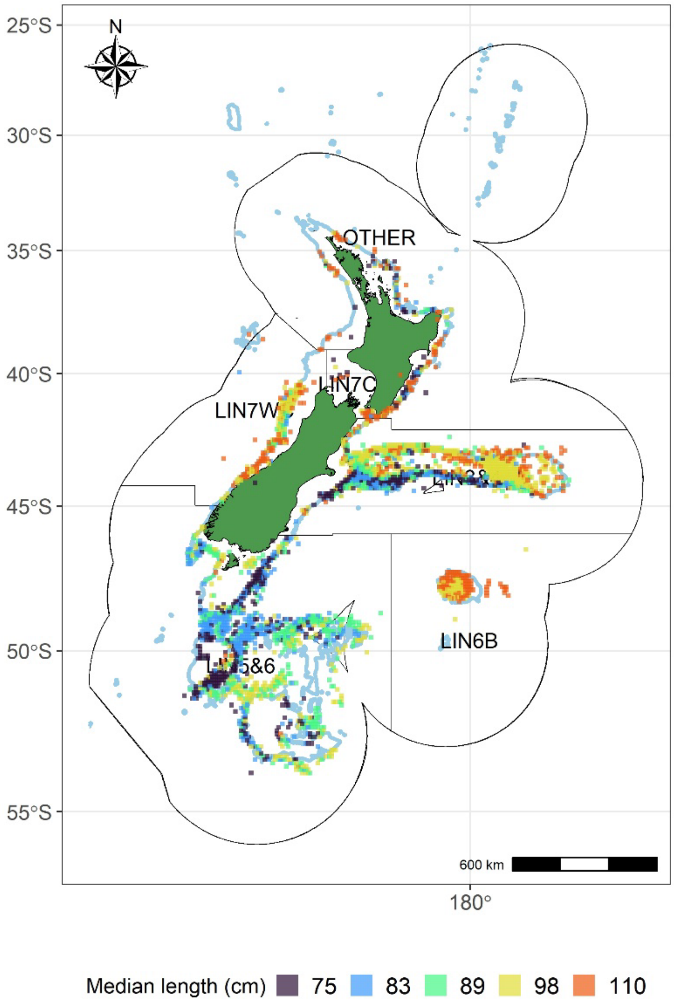

Figure 5: Spatial tree regression of median ling length. The 500 m depth contour is plotted in light blue.

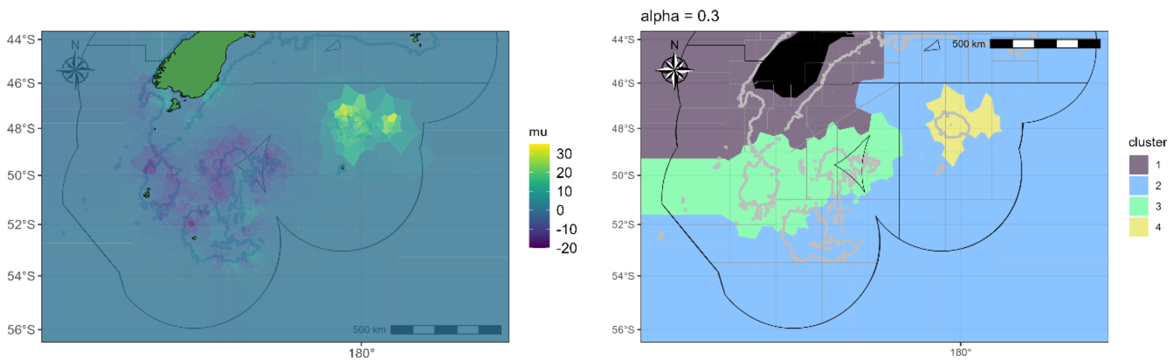

Figure 6: The spatial effect for the optimum INLA model (left) and the optimised cluster of the outcomes (right). Mu is the deviance from the mean length.

3.3 Age data

Raw age data (Figure 7) and the associated von Bertalanffy growth curves (Figure 8) indicated that ling in LIN 5&6 had a different growth curve from all other stocks. Their growth diverged from the other stocks from about age 10 and they grow to a smaller maximum length. This difference is well established: there was an adequate sampling of ling aged 10–30 in LIN 5&6 (Figure 7). Based on age data, LIN 5&6 seemed to be different from all other stocks including LIN 6B. The difference in growth between LIN 5&6 and LIN 6B was unlikely to be temperature-related as both areas had similar temperatures.

Scaled age frequencies of LIN 5&6 (Figure 9) and LIN 3&4 (Mormede et al. 2022) indicated that bottom longlines caught ling in these areas from ages 5 up to 25 years old, with relatively stable recruitment. Scaled length frequency distributions for LIN 6B, indicated that bottom longlines also caught ling from ages 5 to 25 years old, but that the LIN 6B area had episodic recruitment (Figure 9). However, the limited observer data available for LIN 6B limited the usefulness of this analysis.

Estimated recruitment variability was not consistent between the LIN 3&4, LIN 5&6 and LIN 6B stock assessment models (Fisheries New Zealand 2023), although recruitment in LIN 6B was expected to be poorly estimated due to the limited amount of data to inform recruitment estimates.

Length data for ling on the Puysegur plateau indicated that fish in that area had a different median length from those elsewhere in the Sub-Antarctic (Figure 5 and Figure 6), and hence may have a different growth rate. However, estimated von Bertalanffy growth rates for ling on the Puysegur plateau were almost identical to ling in the rest of LIN 5&6.

Because of the difference in growth of ling in LIN 5&6 compared with the other stocks (Figure 8), age-length data were used to investigate the likely boundary of the LIN 5&6 stock with adjoining stocks. Results showed that the current boundary split (Figure 1 and Figure 2), located in Statistical Area 032 in the west and around Statistical Area 025 in the east, was likely to be adequate (Figure 10) to delineate the stock boundaries. Ageing otoliths in Statistical Area 025 would help to confirm the eastern boundary.

The patterns in the age data seemed to indicate that LIN 6B were likely to be a different stock from either LIN 5&6 or LIN 3&4.

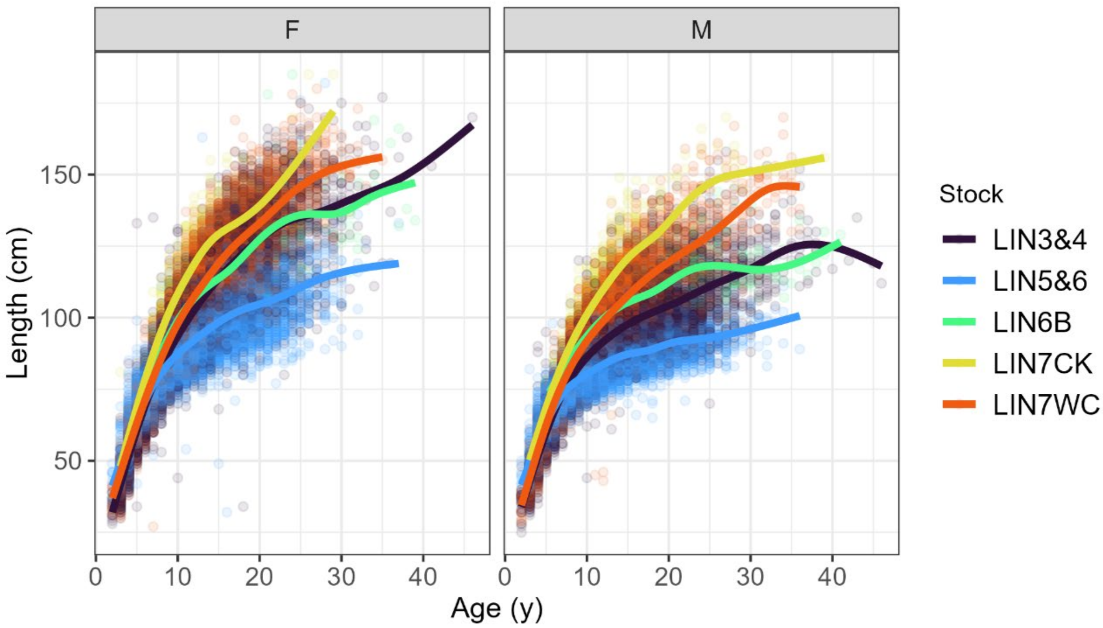

Figure 7: Raw length age relationship of ling by stock for all years combined. Loess curves for each stock are also plotted (solid lines).

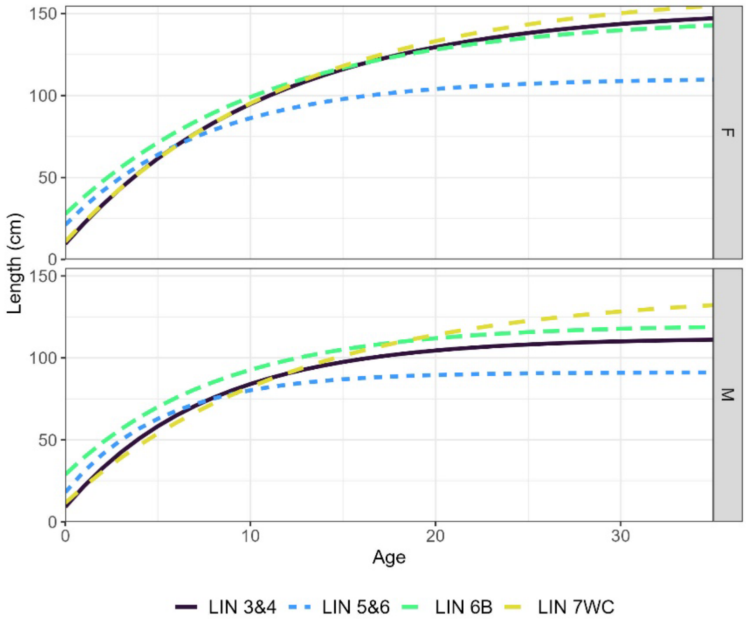

Figure 8: von Bertalanffy curves for ling in four New Zealand ling stocks.

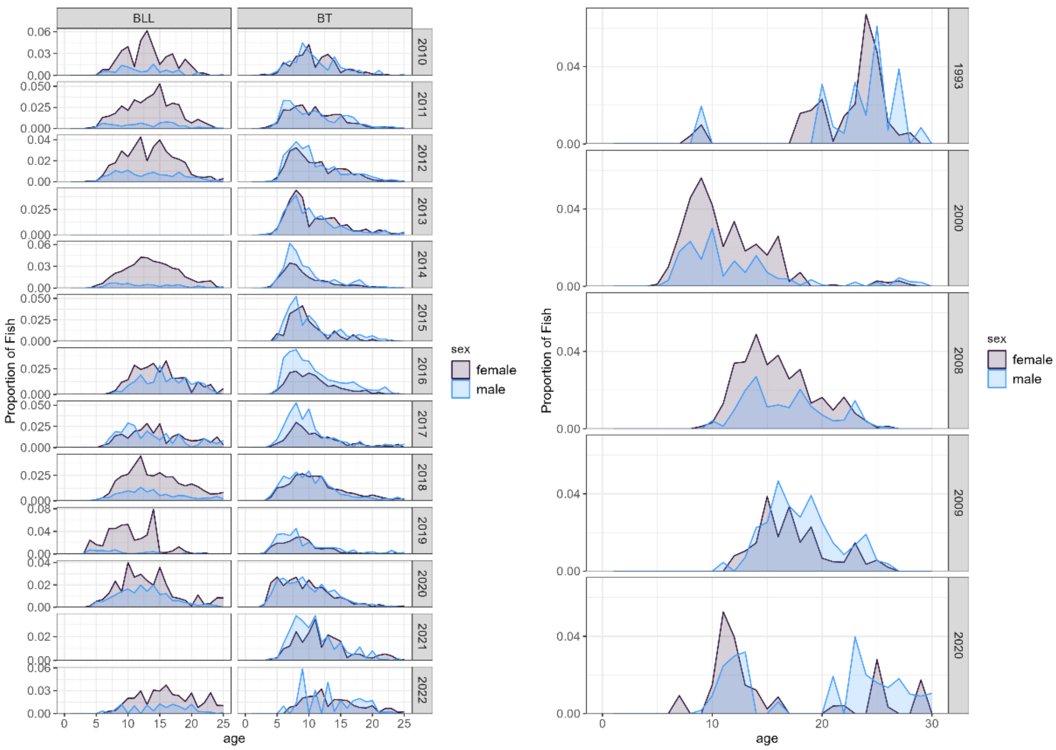

Figure 9: Scaled age frequency of ling in LIN 5&6 bottom longline (BLL) and bottom trawl (BT, left) and LIN 6B bottom longline (right) for the recent years where data were available.

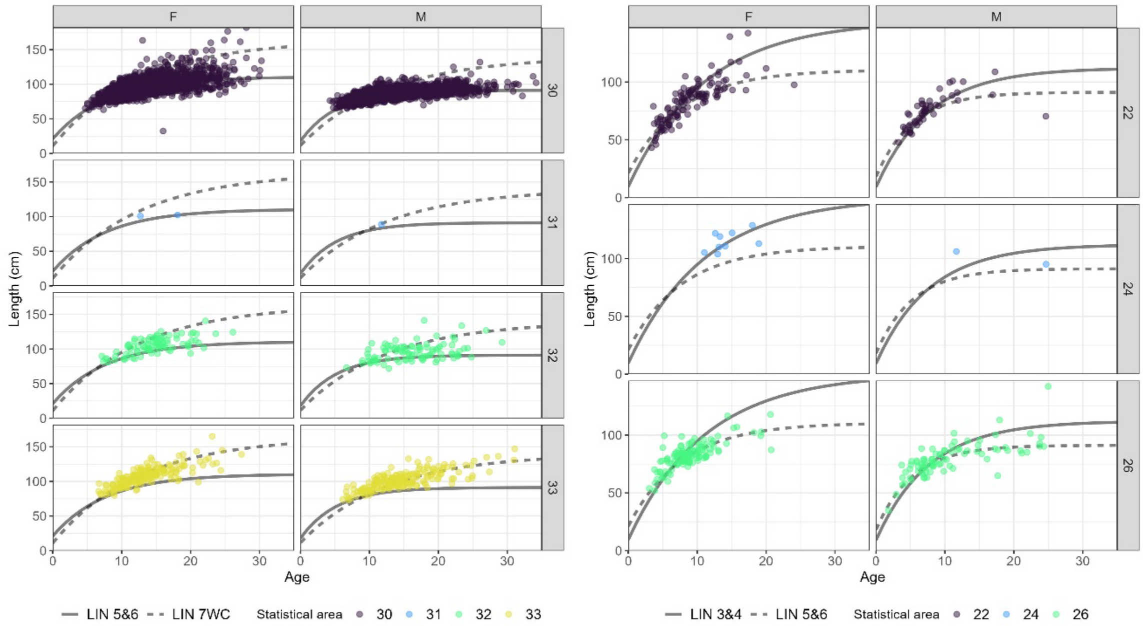

Figure 10: Length-age data by sex (columns) and Statistical Area (rows) and the associated von Bertalanffy curves for (left plots) ling near the LIN 5&6 and the LIN 7WC boundary and (right plots) ling near the LIN 5&6 and LIN 3&4 boundary.

3.4 Maturity data

Maturity at age curves indicated that ling in LIN 3&4 matured at older ages than ling in LIN 5&6 or LIN 7WC, while LIN5&6 and LIN 7WC ling had similar ages of maturation (Horn 2022). Maturity at age was not available for ling in LIN 6B but observer data indicated that all females that were sampled during the spawning season were mature, irrespective of length.

The observer-based estimates of proportion spawning by month also showed that spawning was much more protracted in LIN 6B than in the other stocks (Figure 11). Hence the maturity data was more consistent with the assumption that LIN 6B was a different stock from LIN 5&6 or LIN 3&4.

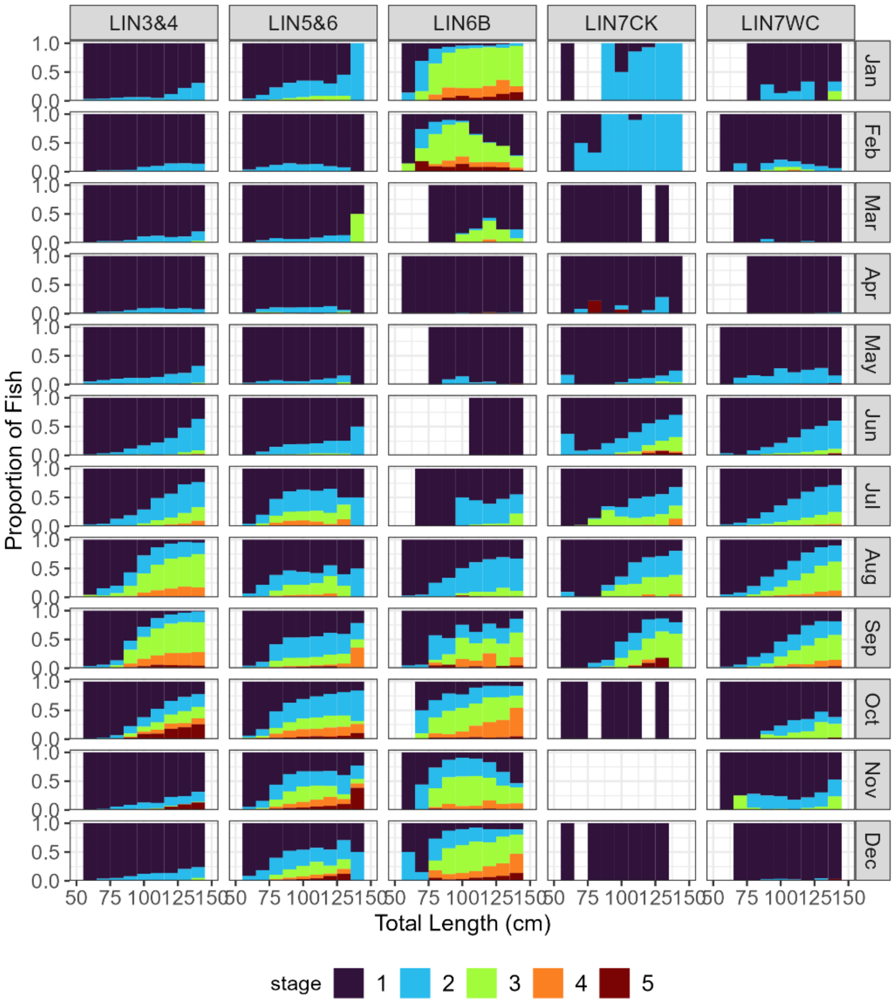

Figure 11: Proportion of ling at length in each maturity stage by month based on observer data. Spawning is defined as maturity stages 3 and 4.

3.5 Standardised CPUE

Standardised catch per unit effort (CPUE) indices were developed for the different ling stocks using either generalised linear modelling (GLM) or spatially explicit modelling of the catch and effort data within each stock. The standardisation methods and data used were detailed in Mormede et al. (2024a).

Comparison of the GLM CPUE indices did not suggest any evidence for different trends between the different stocks, although the data were not particularly informative for LIN 6B (Figure 12).

The spatially explicit CPUE indices indicated some small differences in the trends between each stock, particularly in recent years (Figure 13). However, while the spatially explicit CPUE indices suggested some evidence for LIN 6B being a separate stock, this was relatively weak.

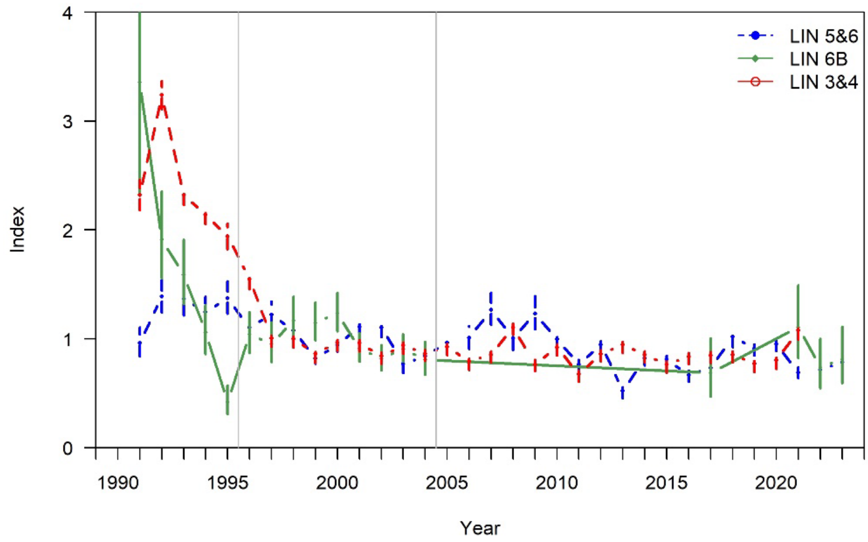

Figure 12: GLM-based CPUE indices for ling in LIN 3&4, LIN 5&6, and LIN 6B (sold lines) and 95% confidence intervals (vertical lines). The LIN 3&4 standardisation was from Mormede et al. (2022) and the LIN 5&6 and LIN 6B CPUE indices were from Mormede et al. (2024a).

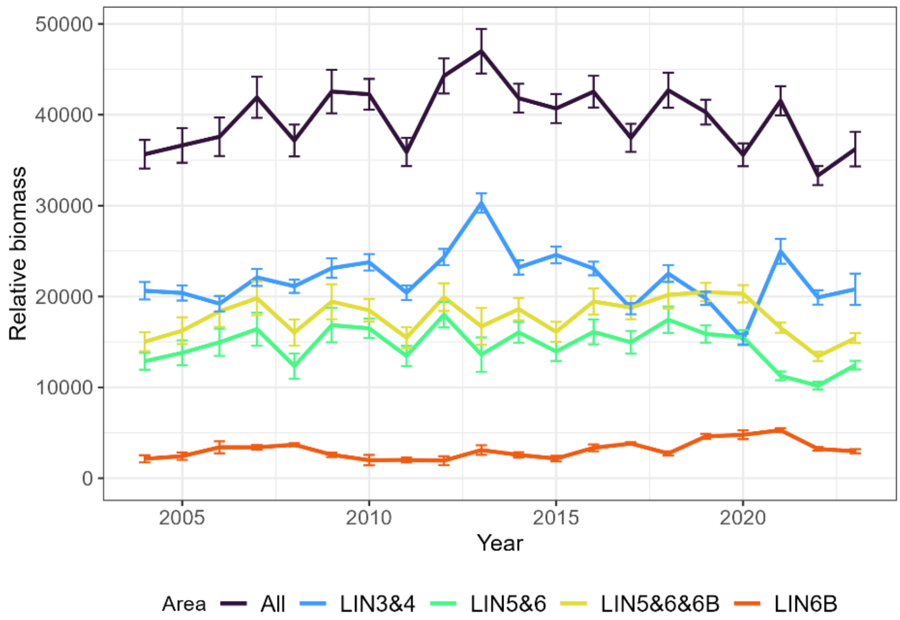

Figure 13: Spatially explicit CPUE indies for ling for the different stocks (solid lines) with CV (vertical lines) (Mormede et al. 2024a).

4. DISCUSSION

The different age, length, and maturity data for ling in the Sub-Antarctic were used to help elucidate the stock structure in LIN 5&6 and LIN 6B. Previous work suggested that LIN 5&6 and LIN 6B form a single stock with differences in age and length explained by movement of ling between the areas (Horn 2022). Alternative hypotheses include LIN 3&4 and LIN 6B as a single stock, or LIN 6B as its own independent stock.

Based on the present analysis, it is unlikely that LIN 6B is part of a single stock with LIN 3&4: although these two areas are next to each other and shared similar growth rates, other data did not support this hypothesis.

It is possible that LIN 6B could be a satellite population of the LIN 5&6 stock, as previously suggested by Horn (2022), particularly since most fish in LIN 6B were mature and the LIN 6B age frequencies suggest that recruitment to the area has been episodic. However, other biological parameters such as growth indicate that LIN 6B could be a different stock from LIN 5&6.

The LIN 6B fishery was mostly carried out by bottom longliners, with episodic fishing and limited observer coverage (Mormede et al. 2024a, 2024c). The limited quantity and quality of data covering this area limited the ability to categorically attribute LIN 6B either as a part of LIN 5&6 or as a separate stock. Moreover, too little data were available to be able to inform a stand-alone stock assessment for LIN 6B. Without additional information, assessing LIN 6B as a separate stock would be difficult and it will be necessary to assess it as part of a single combined LIN 5&6 and LIN 6B stock. In order to collect further evidence that the population in that region is performing differently from ling in LIN 5&6, continued monitoring of ling in LIN 6B will be needed.

5. FULFILLMENT OF BROADER OUTCOMES

As required under Government Procurement rules[4], Fisheries New Zealand considered broader outcomes (secondary benefits such as environmental, social, economic or cultural benefits) that would be generated by this project.

Whakapapa links all people back to the land, sea, and sky, and our obligations to respect the physical world. This research aims to ensure the long-term sustainability of ling stocks, for the good of the wider community (including stakeholders and the public) and the marine ecosystems that ling inhabit. This project supports Māori and regional businesses, diversity and inclusion, and our research is inextricably linked to the moana from the work it carries out and the tangata whenua it supports.

As part of this project, the team has continued to build capacity and capability in fisheries science and stock assessment, its commitment to zero waste and carbon neutrality, environmental stewardship and social responsibility.

6. ACKNOWLEDGEMENTS

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