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Age-based growth dynamics analysis of recreationally- vs commercially-caught snapper (*Chrysophrys auratus*) in SNA1 management zone

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ABSTRACT

This study examines age and growth-based population dynamics of snapper (*Chrysophrys auratus*) in the SNA1 management area, comparing recreationally- and commercially-caught fish. Fishing gear selectivity influenced age and size distribution, with recreationally-caught snapper (Rod & Reel) displaying a broader range (3–28 years; 260–830 mm SL) than commercially caught snapper (Netting) (2–13 years; 240–439 mm SL). The modal age class was 6–7 years for recreational catches and 5 years for commercial catches, while modal size classes were 300–319 mm and 360–379 mm SL, respectively. Von Bertalanffy Growth Function (VBGF) parameters revealed a slightly higher asymptotic length ($L\infty$) for recreationally-caught snapper (433.48 mm SL) compared to commercially-caught (406.51 mm SL), though both exhibited similar growth coefficients ($K = 0.21$ and 0.22). Likelihood Ratio Tests and 95% confidence ellipses confirmed significant growth differences between fisheries. However, these differences likely reflect disparities in age and size structures rather than intrinsic biological variation. Our findings emphasise the importance of considering fishery gear selectivity when evaluating growth dynamics and underscore the need for ongoing monitoring to support sustainable snapper management in SNA1.

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Introduction

The New Zealand snapper (*Chrysophrys auratus*) is a species of significant ecological and socio-economic importance (Parsons et al. 2014). As an abundant meso-predator, snapper play an essential role in the trophodynamics of coastal ecosystems (Shears and Babcock 2002). The accessible coastal distribution and relative abundance of snapper have made them targets for both recreational and commercial fisheries, with stocks historically subjected to intensive fishing pressure (Willis et al. 2003; Paul 2014). The introduction of the quota

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management system (QMS) in 1986 aimed to provide sustainable management of fisheries within New Zealand's exclusive economic zone, setting and controlling harvest levels and total allowable catch limits to enable exploited stocks to replenish. Snapper exhibit a long life-span, reaching up to 60 years, with individuals growing to a maximum length of 100 cm (Leach 2006). Age-based analysis of snapper from the Hauraki Gulf has revealed no sexual dimorphism in growth rates (Paul 1976; Crossland 1981). Snapper are a demersal species occupying rocky reefs, and sandy and muddy bottoms down to 200 m depth, although commonly found between 15 and 60 m (Parsons et al. 2011, 2014). Commercial fishing, primarily reliant on nets, is designed to capture large schools of fish, whereas recreational fishing, using rod-and-reel, typically allows for more selective harvesting.

This study aims to compare the age and growth-based population dynamics of recreationally- and commercially-caught snapper within the SNA1 management zone. SNA1 is the largest and most productive snapper stock in New Zealand, making it a critical region for assessing fishery impacts (Crossland 1982; Gilbert et al. 2000; Hurst et al. 2000). By analysing age structure, size distribution, and growth parameters, we seek to determine whether significant differences exist between these two fishery sectors and how gear selectivity may reflect growth dynamics. These insights will contribute to a more comprehensive understanding of snapper population structure and inform future fisheries management strategies.

Material and methods

Sample collection

Between 2016 and 2021 post-processed snapper frames were acquired from recreational fishers from Doubtless Bay and Hauraki Gulf on the eastern coast of the North Island of New Zealand, which sit within the SNA1 snapper management area. For commercial samples, post-processed snapper frames were purchased from Sanford New Zealand, who use Standard Trawl Fishing (STF) and Precision Seafood Harvesting (PSH) to capture 90% of their snapper quota in SNA1. The Sanford samples were caught on the 28th of February 2017. In total, 223 recreational and 220 commercial samples were measured for standard Length (SL) and had their sagittal otoliths removed, cleaned and stored for age analysis. It should be noted that the legal size-limit for snapper is measured by fork length (FL) and not SL; 25 cm FL for commercially-caught snapper, and 30 cm FL for recreationally-caught snapper.

Age estimation

Age estimation was conducted using thin transverse sections (≈500 µm) of sagittal otoliths (Secor et al. 1995). Age was established by counting the opaque growth rings, which appear as dark bands under transmitted light, with the aid of a 20× magnified camera-mounted compound microscope. The annual periodicity of opaque and translucent zones in snapper otoliths has previously been confirmed by Francis et al. (1992).

Population parameters

The distribution of size and age class frequencies was analysed to understand growth patterns and longevity. The size and age relationship of snapper was modelled for recreational and commercial-caught fish using the von Bertalanffy Growth Function (VBGF) (Kimura 1980) $\mathbf{L(t) = L\infty\ [\ 1 - exp - K\ (t - t0)\ ]}$, where $\mathbf{L(t)}$ is the mean length of the fish at age $\mathbf{t}$; $\mathbf{L\infty}$ is the asymptotic length; $\mathbf{K}$ is the growth rate constant, which indicates how quickly the fish approaches its asymptotic length; and $\mathbf{t0}$ is the theoretical age at which the fish's length would be zero. Due to the lack of very young specimens, we decided not to constrain our VBGF model to an arbitrary fixed t0. To assess potential differences in von Bertalanffy growth parameters between recreationally- and commercially-caught snapper, Likelihood Ratio Tests (LRT) were conducted following the methods of Kimura (1980) and Cerrato (1990). The null hypothesis, stating that growth does not differ between populations, was evaluated at an alpha level of 0.05, with q (degrees of freedom) denoting the number of constrained parameters. Additionally, 95% confidence ellipses were constructed around least squares estimates of L∞ and K to further examine fishery-based growth variation. Non-overlapping confidence regions will be interpreted as evidence of significant differences in growth parameters.

Results

Age distribution stretched from 2 to 13 years for commercially-caught snapper, and 3 to 28 years for recreationally-caught snapper (Figure 1). Five-year-olds were the modal age class for commercially-caught snapper, while 6 and 7-year-olds were the most common ages caught by recreational fishers. Evidently, the commercially-caught cohort were much younger than their recreationally-caught counterparts. The size distribution of

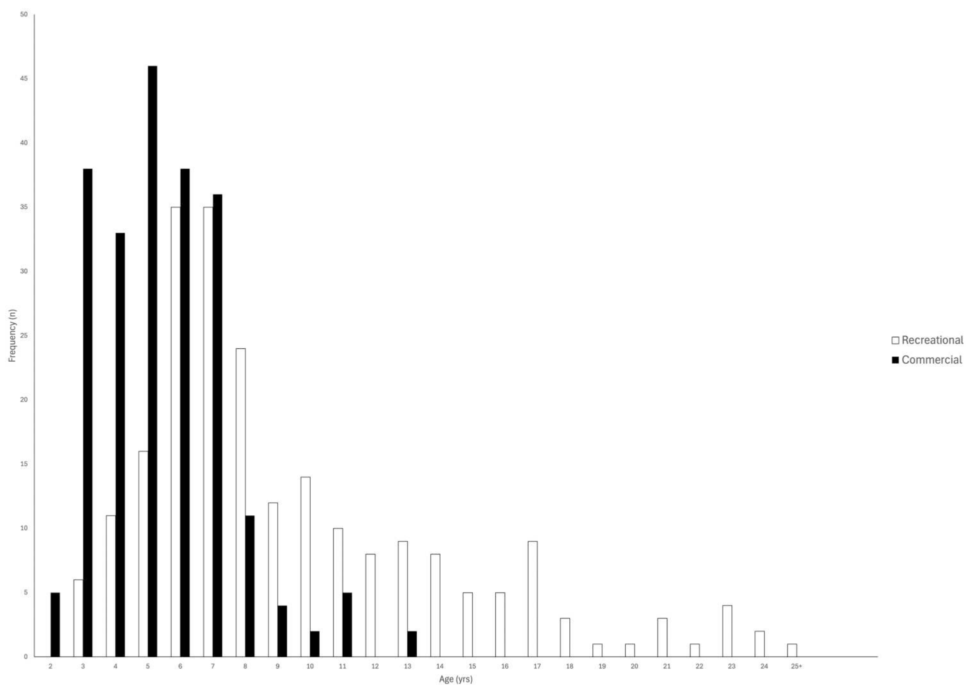

Figure 1. Age distribution of recreationally- and commercially-caught snapper *Chrysophrys auratus* from SNA1.

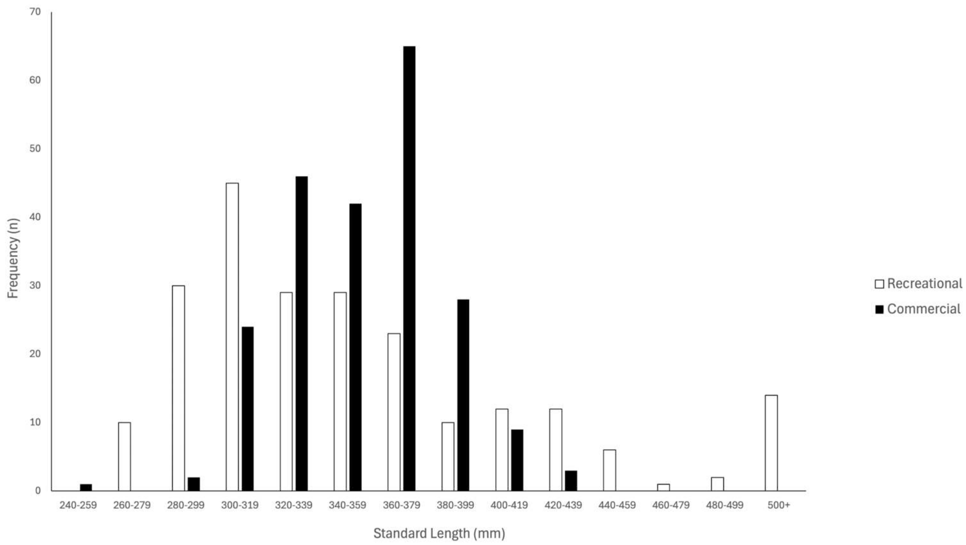

Figure 2. Size distribution of recreationally- and commercially-caught snapper *Chrysophrys auratus* from SNA1.

recreationally-caught snapper in this study ranged from 260 to 830 mm SL, while commercially-caught snapper were distributed across a much smaller distribution, ranging from 240 to 420 mm SL (Figure 2). The two key VBGF parameters of *L*⍰ and *K* revealed the mean asymptotic length for the recreationally-caught population was slightly higher at 433 mm(SL), compared to 406 mm for commercially-caught snapper, while they both had similar growth coefficient of 0.21 and 0.22, respectively. The VBGF growth trajectories have been modelled in Figure 3. The LRT comparing growth parameters between recreationally-caught and commercially-caught snapper indicated a statistically significant difference ($P < 0.05$). Similarly, confidence ellipses (Figure 4) constructed around L∞ and K for both fisheries showed non-overlapping regions, further confirming significant growth differences.

Discussion

Age and size distribution analysis of recreational and commercial datasets revealed expected yet noteworthy trends. Commercially-caught snapper exhibited a constrained age and size range compared to their recreational counterparts (Figures 1 & 2). This disparity likely reflects gear selectivity, as commercial fishing methods such as netting tend to target large aggregations of fish with relatively uniform size distributions, whereas rod-and-reel fishing allows for greater selectivity in catch composition. This pattern aligns with previous studies demonstrating that schooling fish often exhibit reduced heterogeneity in age and size due to aggregative behaviour (Kasumyan and Pavlov 2023). The application of the VBGF indicated that recreationally-caught snapper exhibited a slightly higher asymptotic length (433 mm SL) compared to commercially-caught snapper (406 mm SL). However, both groups displayed comparable growth coefficients (K = 0.21 and 0.22, respectively), suggesting that the overall growth rate remains largely

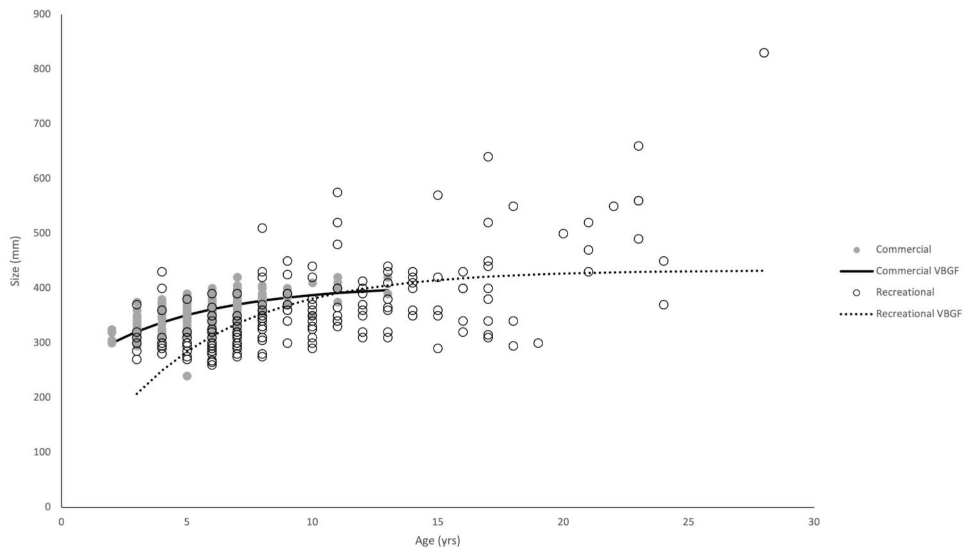

Figure 3. von Bertalanffy growth trajectories from recreationally- and commercially-caught snapper *Chrysophrys auratus* from SNA1.

consistent across fisheries. These findings are supported by previous research on snapper populations, which indicates that while growth trajectories may exhibit slight variability due to environmental factors and fishing pressure, underlying growth patterns tend to remain stable (Parsons et al. 2015).

Despite statistical significance in the Likelihood Ratio Test (LRT) and non-overlapping confidence ellipses (Figure 4), caution is warranted when interpreting these

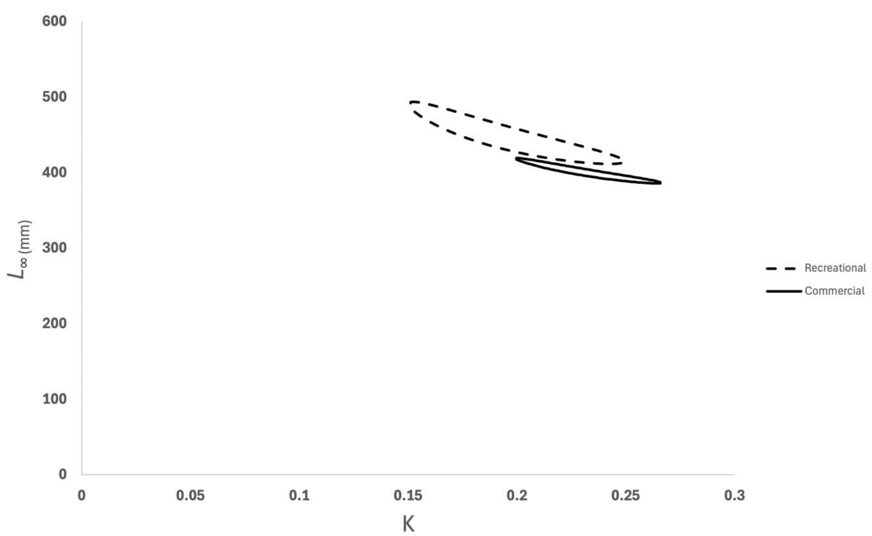

Figure 4. Comparison of VBGF parameters for recreationally- and commercially-caught snapper *Chrysophrys auratus* in SNA1, depicting 95% confidence regions around least squares estimate of K and L∞.

results. As indicated by the close proximity of the confidence ellipses, the observed differences in growth parameters may be primarily driven by the disparate age and size structures of the two fisheries rather than inherent biological differences between the stocks. The absence of a fully representative dataset, particularly the limited inclusion of older fish within the commercially-caught sample, further complicates direct comparisons. Given that commercial fishing predominantly captures younger, mid-sized individuals, the growth model for this cohort may be skewed toward earlier life stages, whereas the recreational sector provides a broader representation of older age classes. This structural bias underscores the challenges of comparing growth parameters across fisheries with distinct selectivity pressures.

The implications of these findings extend beyond methodological considerations and raise important questions about the management of the SNA1 snapper stock. If commercial and recreational fisheries are effectively harvesting from the same stock, but with differential selectivity, it is critical to assess how this impacts long-term population dynamics. Previous studies have highlighted the role of selective harvesting in altering population demographics and growth trajectories (Paul 2014), with implications for fisheries management strategies, particularly in mixed-use fisheries where both commercial and recreational sectors exert significant pressures. Given the history of intensive fishing pressure in the SNA1 region, and the long lifespan of snapper, continued monitoring is essential to detect potential long-term shifts in growth dynamics.

While our findings indicate statistically significant differences in growth parameters between recreationally- and commercially-caught snapper, these differences appear to be driven primarily by the distinct age and size compositions of the two datasets rather than fundamental biological variation between fishery components. Given the challenges associated with direct growth comparisons across fisheries with differing gear selectivity pressures, we caution against overinterpretation of these results. Instead, our study highlights the importance of considering age and size structure biases when evaluating growth dynamics and underscores the need for continued monitoring to ensure sustainable management of the SNA1 snapper stock.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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