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West Coast Demersal Scalefish Resource

2025 Assessment

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Resource Assessment Report No. 2

West Coast Demersal Scalefish Resource

2025 Assessment

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Important disclaimer

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Executive Summary

The West Coast Demersal Scalefish Resource (WCDSR) comprises over 100 species inhabiting inshore (20-250 m deep) and offshore (>250 m deep) waters of the West Coast Bioregion (WCB; north of Kalbarri to east of Augusta). The WCDSR is primarily targeted by commercial, charter and recreational boat-based line fishers, including the commercial West Coast Demersal Scalefish (Interim) Managed Fishery (WCDSIMF). Indicator species selected for monitoring and assessing the status of the inshore suite of the WCDSR include Snapper, WA Dhufish and Baldchin Groper, while indicators for the offshore suite include Hapuku, Bass Groper and Blue-eye Trevalla.

The WCDSR is more than halfway through a 20-year recovery plan to recover stocks by 2030. As outlined in the WCDSR harvest strategy, the recovery of the resource is currently monitored through annual reviews of total removals (including retained catches and estimates of post-release mortality) against specific recovery benchmarks for each sector, as well as periodic stock assessments of each indicator species (DPIRD 2021). The 2025 WCDSR assessment presented in this report incorporates catch and effort information collected up to 2024 (inclusive), as well as biological data on the sizes and ages of fish sampled from commercial and recreational catches in each management area (Kalbarri, Mid-West, Metropolitan and South-West) up until 2021-22 (inclusive).

Total removals of demersal scalefish by commercial fisheries in the WCB in 2024 (291 t) were well above the 240 t recovery benchmark in place for that year. The total removals of key demersal scalefish species collectively caught by boat-based recreational and charter fishers in the WCB in 2023-24 (217 t), derived from the 2023-24 survey of private boat-based fishing and reported charter catches in the same year, were also well above the 135 t recovery benchmark for this sector. These data show that the substantial management changes implemented in 2023 have not been effective at reducing fishing mortality to the level required to support recovery.

The WCDSR provides a high social amenity to fishers, with the indicator species representing primary targets for recreational fishers in the WCB. The estimated gross value of product (GVP) of the commercial WCDSIMF was $1-5 million in 2024.

Snapper

The integrated model (Level 5) assessment of Snapper in the northern (Kalbarri and Mid-West) and southern (Metropolitan and South-West) management areas of the WCB indicated limited changes in stock status since the 2021 assessment. The estimated female relative spawning biomass (B_{rel}) for Snapper in the northern WCB in 2024 remained below the limit reference level of 0.2, while the corresponding estimate for the southern WCB was at the limit level. Estimated fishing mortality (F) for Snapper in the WCB in 2024 exceeded acceptable levels. Snapper in the northern and southern WCB are classified as **Inadequate** and the risk to both stocks is assessed as **Severe**. Model projections show that B_{rel} for the northern and southern Snapper stocks is unlikely to rebuild above the threshold reference level of B_{MSY} by 2030 (Step 2 of the recovery plan), even if catches are reduced to current recovery benchmarks. Although highly uncertain, projections suggest that recovery of stocks to the target level may not occur until 2035-2040 unless current catches are substantially reduced.

WA Dhufish

The integrated model (Level 5) assessment of WA Dhufish in the WCB provided less optimistic estimates of stock status compared to the 2021 assessment. Estimated female

B_{rel} for WA Dhufish at the stock level in 2024 was below the limit reference level of 0.2, with recent trends in B_{rel} estimates indicating minimal recovery in the northern (primarily Mid-West) management areas and declining spawning biomass levels in the southern (Metropolitan and South-West) areas of the WCB. The estimated *F* for WA Dhufish in the WCB in 2024 exceeded acceptable levels. WA Dhufish in the WCB is classified as **Inadequate** and the risk to this stock is assessed as **Severe**. Model projections show that B_{rel} is unlikely to recover to B_{MSY} by 2030 (Step 2 of the recovery plan), even if catches are reduced to the current recovery benchmark. Although highly uncertain, projections suggest that recovery to the target level may not occur until 2040 unless current catches are substantially reduced.

Baldchin Groper

The catch curve and equilibrium biomass analysis (Level 3) assessment of Baldchin Groper in the Mid-West area of the WCB (for which this is an indicator species) provided evidence of some recovery occurring since the last (2014) assessment of this stock. The B_{rel} estimated for both sexes combined was between the limit and threshold reference levels of 0.2 and 0.3, respectively, in 2018-21. Estimates of *F* indicate a reduced exploitation of this stock since the start of the recovery period. The risk to Baldchin Groper in the Mid-West is assessed as **High** and the stock is classified as **Sustainable – Recovering**.

Other Key Target Species

Based on the latest available age composition data, catch curve and per-recruit (Level 3) assessments of Redthroat Emperor (2016-17, North WCB), Breaksea Cod (2013-14, South WCB) and Bight Redfish (2019, South-West management area of the WCB) show lower levels of *F* and greater levels of B_{rel} compared to Snapper, WA Dhufish and Baldchin Groper. The risk to Redthroat Emperor and Breaksea Cod is assessed as **Medium**, and the risk to Bight Redfish is assessed as **Low**. These stocks are classified as **Sustainable – Adequate**.

Offshore Indicator Species

Catch-MSY (Level 1) analyses of catch time series for Hapuku, Bass Groper and Blue-eye Trevalla in the WCB, while highly uncertain and based on strong modelling assumptions, suggest that catches have generally been maintained around and below the estimated MSY for these stocks. The risk to these offshore indicator species in the WCB is assessed as **Medium** and the stocks are classified as **Sustainable – Adequate**.

Ecological Components

Line fishing for demersal species using baited hooks is highly selective for fishes, with catches of species other than the key species only retained in relatively low numbers. As management measures implemented to recover the broader WCDSR are likely to have provided benefits to these minor retained species, the risk to these species is assessed **Medium**.

Limited available bycatch data indicate discards are primarily comprised of fish below their minimum size limits. Line fishing interactions with ETP species are rare and the fishing gear has little physical impact on the benthic environment. As the management of the commercial and recreational fishing sectors targeting the WCDSR restrict catches to a relatively small percentage of the total biomass available (e.g., retained Snapper catches are limited to fish above the minimum legal length), there is limited effect on the food chain. The risks to these ecological components are assessed as **Negligible** or **Low**.

Assessment Overview

Target Stocks

Species/Stock	Risk	Fishing Mortality (*F*)	Relative Biomass (*B*)	Status
Snapper – North WCB	Severe	*F* ≈ Threshold	*B* < Limit	Inadequate
Snapper – South WCB	Severe	*F* > Threshold	*B* ≈ Limit	Inadequate
WA Dhufish	Severe	*F* > Limit	*B* < Limit	Inadequate
Baldchin Groper	High	Limit > *F* > Threshold	Limit < *B* < Threshold	Sustainable – Recovering
Redthroat Emperor	Medium	Limit > *F* > Threshold	Threshold < *B* < Target	Sustainable – Adequate
Bight Redfish	Low	*F* ≈ Target	*B* >Target	Sustainable – Adequate
Breaksea Cod	Medium	*F* ≈ Threshold	Threshold < *B* < Target	Sustainable – Adequate
Hapuku	Medium	Catches fluctuate around and below MSY		Sustainable – Adequate
Bass Groper	Medium	Catches fluctuate around and below MSY		Sustainable – Adequate
Blue-eye Trevalla	Medium	Catches fluctuate around and below MSY		Sustainable – Adequate

As the 2024 estimates of biomass of the indicator species Snapper and WA Dhufish remain at or below the limit reference levels, and with fishing mortality estimates for these species remaining above acceptable levels to allow for recovery, the status to these stocks is assessed as Inadequate (Severe risk). Although stocks of other assessed species currently have lower risks to sustainability, the harvest strategy and management of the WCDSR is focused on the status of Snapper and WA Dhufish as the key target and indicator species.

As the first step of the WCDSR recovery strategy (to recover stocks of indicator species above the limit reference level by 2020; DPIRD 2021) was not met, these assessment outputs support the need for the additional management actions taken in 2023 to further reduce fishing pressure on these stocks. However, at the current levels of catch (exceeding updated recovery benchmarks), stocks of Snapper and WA Dhufish are unlikely to rebuild to the threshold level of B_{MSY} by 2030, and thus Step 2 of the recovery plan is not expected to be met. In addition, stocks are unlikely to recover to their target levels before 2035-2040 unless current catches are substantially reduced.

Ecological Components

Feature	Risk	Comments
Other Retained Species	Medium	Reduced fishing effort and catches since management measures implemented to recover resource
Bycatch Species	Low	Highly selective fishing methods
ETP Species	Negligible	Highly selective fishing methods
Habitats	Negligible	Little direct impact on benthic habitats
Ecosystem	Low	Limited effect on food chain and management limits proportion of stocks exploited

Although the overall risk to the WCDSR is assessed as Severe (following the indicator species approach, based on the highest risk for target stocks), risks to other ecological components affected by fishing activities targeting the WCDSR are assessed as Acceptable (Medium risk or lower). In line with the harvest strategy, management should continue to focus on meeting objectives relating to the sustainability of target stocks.

Socio-Economic Components and External Drivers

Feature	Risk	Comments
Economic	High	Level 2: GVP $1-5 million
Social	High	Level 5: Primary target for recreational sector
External Drivers (Climate)	Medium sensitivity	Low–Medium sensitivity for inshore and offshore indicator species. Highest level reported.
External Drivers (Other)	Low	Commonwealth trawl fishing occurs rarely.

Due to the need for additional management action to recover the WCDSR, the risk to the current economic returns and social values is assessed as High.

1 Background

1.1 Resource Overview

The West Coast Demersal Scalefish Resource (WCDSR) comprises over 100 species in inshore (20-250 m deep) and offshore (>250 m) demersal habitats of the West Coast Bioregion (WCB), which are exploited primarily by boat-based commercial, charter, and recreational line fishers (Fisher and Fairclough 2024). The indicator species for inshore waters include Snapper, WA Dhufish and Baldchin Groper (for the Mid-West area only), while indicators for offshore waters include Hapuku, Bass Groper and Blue-eye Trevalla (DPIRD 2021).

The WCDSR is currently managed under a 20-year recovery plan (DPIRD 2021). The 2021 assessment demonstrated limited recovery of indicator species (Fairclough et al. 2021) and showed that further management action to reduce catches was required to recover the resource by 2030. The Minister for Fisheries therefore announced a 50% reduction in the original catch recovery benchmarks, as recommended by a stakeholder-based WCDSR Harvest Strategy reference group.

Management measures implemented in 2023, aimed to limit total removals (retained catch and post-release mortality, PRM) of demersal scalefish in the WCB to 375 t, included reductions in effort entitlement (fishing hours) for the main commercial fishery targeting the WCDSR, a tag-based quota system for the charter fishery, and a 6-month closed season for boat-based recreational fishing for demersal scalefish in the WCB.

As part of a $11.6 million support package provided by the State Government for a range of research and management initiatives for the WCDSR, a Voluntary Fisheries Adjustment Scheme (VFAS) was completed in 2023 to buy out commercial entitlement in the West Coast Demersal Scalefish (Interim) Management Fishery (WCDSIMF). This resulted in the surrender of more than 8,900 units of entitlement, equating to approximately 38.5 t of demersal scalefish catch that was re-allocated to other commercial fisheries and the recreational (including charter) sector while in recovery.

1.2 Assessment Approach

The different methods used by the Department to assess the status of aquatic resources in WA have been categorised into five broad levels, ranging from relatively simple analysis of catch and effort information, through to the application of more sophisticated analyses and models that incorporate biological data (e.g., Braccini et al. 2021; Newman et al. 2024). The relevance and applicability of each assessment level varies among stocks and is determined based on the level of ecological risk, the biology and population dynamics of the relevant species, the characteristics of the fisheries exploiting the species, and data availability.

Irrespective of the types of assessment methods used, all stock assessments undertaken by the Department apply a risk-based, weight-of-evidence approach. This requires the consideration of each available line of evidence, including outputs from quantitative (empirical and/or model-based) analyses, as well as qualitative lines of evidence such as biological and fishery information that describe the inherent vulnerability of the species to fishing. For each stock, all the lines of evidence are considered within the Department’s ISO 31000 based risk assessment framework to derive an overall risk status from the combinations of consequence and likelihood scores (Fletcher 2015).

1.3 Scope

This report provides a periodic assessment for the WCDSR, following the principles of ecosystem-based fisheries management (EBFM; Fletcher 2015). The document provides information relevant to monitoring of the broader resource (Section 2), as well as more detailed stock assessment outputs for key target species (Section 3). Additional information relevant to assessing the risk to other ecological components affected by fishing activities targeting the WCDSR is presented in Section 4.

As outlined in the WCDSR Harvest Strategy, the recovery of the resource is currently monitored through annual reviews of available catch information for the demersal suite and key species/groups, as well as periodic assessments of stock status for each indicator species (DPIRD 2021). The annual catch review process considers estimates of the total removals of species in the WCB, comprising both retained catches and estimates of PRM. These are compared annually to specified recovery benchmarks for each sector.

Stock assessments are conducted periodically for the key WCDSR indicator species (Snapper and WA Dhufish across the WCB, and Baldchin Groper in the Mid-west), as well as other important inshore or offshore species when data are available. Level 3 and Level 5 assessments (see Appendix 1) provide estimates of relative spawning stock biomass (B_{rel}) and fishing mortality (F). These estimates are compared to internationally recognised biological reference points to assess status and risk to stocks, and to help ensure the rate of recovery is sufficient to rebuild stocks within the recovery timeframe.

This 2025 assessment provides estimates of B_{rel} and F for the three inshore indicator species (Snapper, WA Dhufish and Baldchin Groper) in addition to Redthroat Emperor, Bight Redfish and Breaksea Cod. Collectively, these six species comprise more than 90% of retained catches by commercial, charter and recreational fisheries combined. The report also includes available information on the three offshore demersal indicator species in the WCB – Hapuku, Bass Groper and Blue-eye Trevalla.

Appendix 1 provides a broad description of the key empirical and model-based analyses undertaken as part of this assessment. Appendix 2 and 3 show model fits to data and outputs from integrated model sensitivity analyses, respectively. The 2025 assessment provides catch and effort information collected up to 2024 (inclusive), as well as biological data on the sizes and ages of fish sampled from commercial and recreational catches in each management area (Kalbarri, Mid-West, Metropolitan and South-West) up until 2021-22 (inclusive).

2 Resource Assessment

2.1 Catch

The WCDSR comprises more than 100 species of demersal scalefish that are targeted in varying proportions by commercial, charter and recreational fishers in inshore and offshore waters of the WCB.

The inshore demersal suite is found in waters 20-250 m deep and collectively contributes more than 95% of demersal catches in the WCB (Table 2.1). Retained catches of inshore demersal scalefish in this region are dominated by six key species, all of which are caught commercially and recreationally (Table 2.1). WA Dhufish, Baldchin Groper and Breaksea Cod are predominantly caught by recreational fishers, whereas Snapper, Redthroat Emperor and Bight Redfish are mostly caught by commercial fishers (Table 2.1).

The offshore demersal suite, which mostly occurs in waters >250 m deep, accounts for less than 5% of overall demersal scalefish catches in the WCB (Table 2.1). Retained catches are dominated by Hapuku and Greybanded grouper (formerly Eightbar grouper; Moore et al. 2022), with smaller catches of Blue-eye Trevalla and Bass Groper also retained primarily by recreational fishers (Table 2.1).

Annual Catch Review

The most recent annual catch review includes information on retained catches and PRM up to 2024 (Figure 2.1), following the reduction in recovery benchmarks and implementation of new management measures for the WCDSR in early 2023. This review is thus undertaken against the recovery benchmarks for the commercial sector (240 t) and the recreational sector (135 t, including 115 t private recreational and 20 t charter) updated in 2023. Note that these benchmarks were further adjusted in late 2024 following the completion of the VFAS. As timeframes for reporting of catch information differ among sectors, data are grouped into 'seasons' to ensure reviews are based on the most up-to-date data. The 2023-24 season incorporates commercial logbook data for the 2024 calendar year, charter data for the 2023-24 financial year and recreational data from the latest Statewide fishing survey (September 2023 to August 2024).

The total removals of demersal scalefish by commercial fisheries in the WCB in 2024 (291 t) were well above the 240 t recovery benchmark in place for that year (Figure 2.1). Despite substantial effort reductions implemented in 2023 across the management areas of the WCDSIMF, the 2024 total removals of Snapper (157 t), WA Dhufish (43 t) and Redfish species (36 t, primarily Bight redfish) by the commercial sector have remained at the previous level.

The most recent estimate of total removals of the key demersal scalefish species caught by boat-based recreational and charter fishers in the WCB (217 t in 2023-24) was well above the 135 t recovery benchmark for this sector (Figure 2.1). Despite the extended closed season in place for private boat-based recreational fishers targeting demersal scalefish in the WCB since 2023, total removals by these fishers in 2023-24 of 195 t (including 61 t Snapper, 95 t WA dhufish and 26 t Baldchin groper), were similar to estimates from 2020-21 (Ryan et al. 2022; 2025). Total removals of demersal scalefish by charter fishers in the WCB reduced from 74 t in 2020-21 to 22 t in 2023-24, with the current tag system successfully maintaining removals at an acceptable level. Since the removal of the minimum legal lengths for WA dhufish, Baldchin groper and Breaksea cod, the estimated PRM component of the recreational sector removals has markedly reduced (from 49 t in 2020-21 to 21 t in 2023-24).

Table 2.1. Retained catches (tonnes, t) of demersal scalefish landed by commercial, charter and recreational fishers in the WCB in 2023-24. Catches are reported for the commercial sector for the 2024 calendar year, charter for the financial year (1 Jul 2023–30 Jun 2024) and recreational catches are reported for the survey year (1 Sep 2023–31 Aug 2024, see Ryan et al. 2025). Note that catches have been rounded and may not add up to totals.

Species	Commercial	Charter*	Recreational*	Total
Total demersal	282	21	175	479
Total inshore	274	20	174	469
Snapper	149	10	49	208
WA dhufish	43	4	90	136
Baldchin groper	11	4	24	39
Bight redfish	36	0.02	0.4	36
Redthroat emperor	13	0.7		14
Breaksea cod	2	0.5	6	8
Western blue groper	6			6
Blue morwong	3	0.1	3	6
Spangled emperor	3	0.6		4
Northern pearl perch	2			2
Red emperor	2			2
Coral trouts	0.3	0.7		1
Rockcods	1			1
Goldband snapper	1			1
Emperors (other)	0.4	0.04	0.3**	0.7
Sea sweep	0.03		0.7	0.7
Sergeant baker	0.002		0.7	0.7
Rankin cod	0.6			0.6
Boarfishes	0.6			0.6
Foxfish	0.05	0.05	0.4	0.5
Other inshore species	2	0.1		2
Total offshore	7	0.4	1	8
Greybanded grouper	4	0.2	0.2	4
Hapuku	2		0.4	3
Bass groper	0.1		0.5	0.6
Blue-eye trevalla	0.2	0.2		0.3

* Top 15 species/groups

** All emperors (Family Lethrinidae), including Redthroat emperor, Spangled emperor

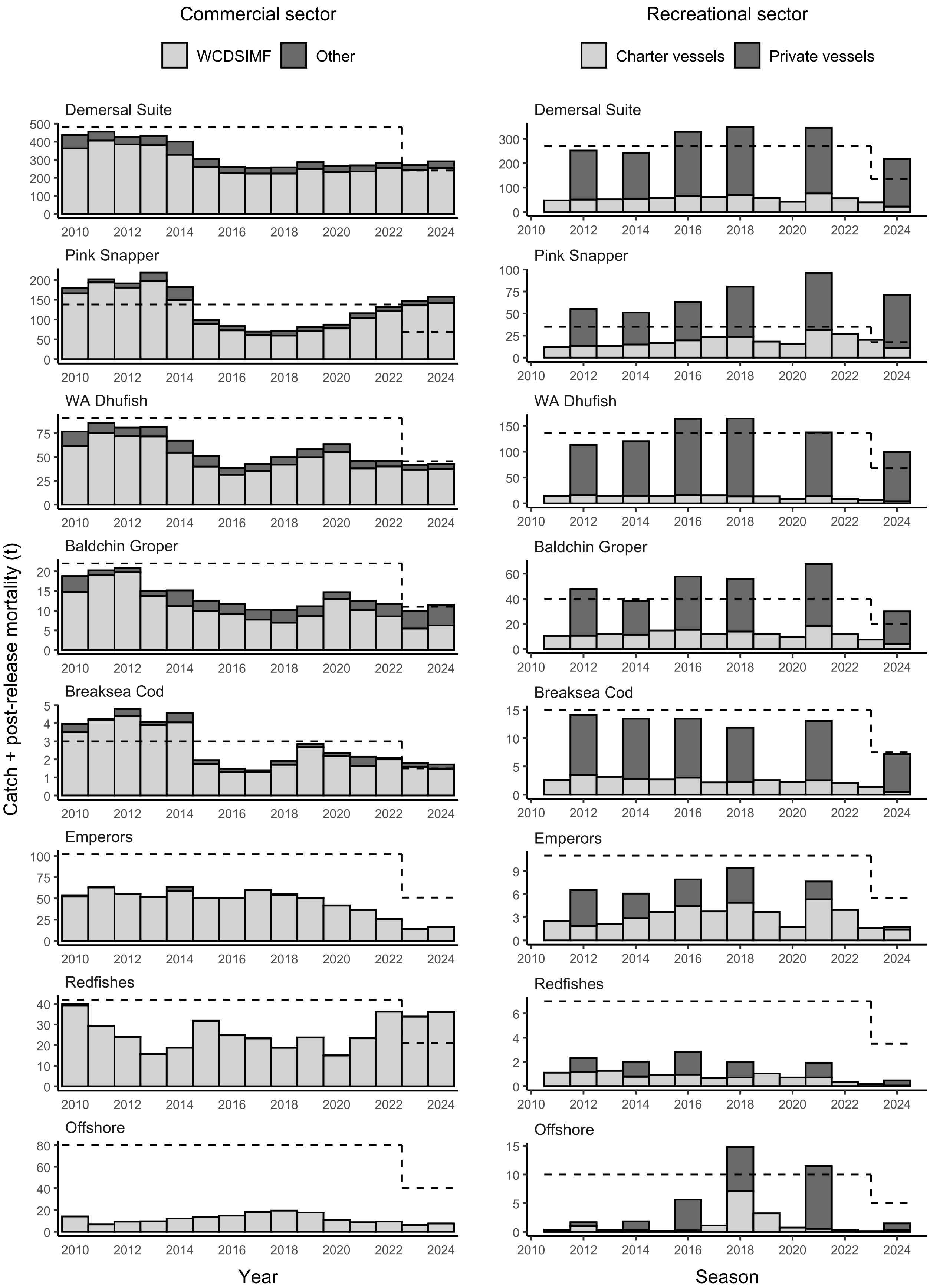


Figure 2.1. Retained catch and estimated post-release mortality (t) of the demersal scalefish suite and key species/groups by each fishing sector against recovery benchmarks.

2.2 Effort

From 2008 to 2024, the number of active vessels in the WCDSIMF has decreased from ~ 50 to 25, with the majority operating in the Mid-West management area (Table 2.2). Since 2015, when effort entitlement was reduced for WCDSIMF fishers in the Mid-West and Kalbarri areas to reduce catches of Snapper, the number of days and hours fished have remained relatively stable (Fisher and Fairclough 2024), before decreasing following further changes to management in 2023. Many of the WCDSIMF fishers also hold licences in other commercial fisheries, with only a small proportion of the vessels operating as full-time line fishers.

The number of charter operators reporting catches of demersal scalefish in the WCB has decreased from more than 80 vessels in the early 2000s to ~ 50-60 vessels since the 2010 management changes, with most of the recent charter activity occurring in the Mid-West (Fisher and Fairclough 2024). In 2023-24, following the implementation of a tag system for managing charter catches of demersal scalefish in the WCB, 40 charter vessels reported catches of key demersal species during 978 fishing trips (Table 2.2).

The Statewide recreational fishing surveys undertaken since 2011-12 show estimated number of boat days, fishing trips and hours fished by boat-based recreational fishers in the WCB declined between 2011-12 and 2013-14 before showing a steady increase back to their 2011-12 levels (Fisher and Fairclough 2024; Ryan et al. 2022). Since the recent changes to management in 2023, the number of days that private recreational vessels are estimated to have fished in the WCB reduced from 308,701 days in 2020-21 to 215,011 days in 2023-24 (Ryan et al. 2025).

Table 2.2. Performance statistics relating to fishing effort (fishing days/trips, number of active vessels) of the key fishing sectors targeting the WCDSR.

Sector	Previous season	Current season	Further description
Commercial (WCDSIMF)	2023: 845 days (28 active vessels)	2024: 794 days (25 active vessels)	WCDSIMF, 2024: Kalbarri: 147 days (4 vessels) Mid-West: 308 days (21 vessels) South-West: 340 days (4 vessels)
Charter	WCB, 2022-23: 1,306 trips (51 vessels)	WCB, 2023-24: 978 trips (40 vessels)	Trips recording catches of top 15 demersal scalefish species in WCB.
Recreational	WCB, 2020-21: 308,701 days	WCB, 2023-24: 215,011 days	Days fished in WCB (boat-based only; Ryan et al. 2025)

2.3 Social and Economic

The WCDSR provides high social amenity to fishers and divers, as well as to consumers by providing commercial fish supply to markets and restaurants. The estimated gross value of product (GVP) for the WCDSIMF in 2024 was $1-5 million. A national social and economic survey recently estimated that recreational fishers across WA contribute $1.1 billion annually to the Australian economy (Moore et al. 2023).

The WCDSR harvest strategy includes indicators to measure the performance of each sector against social and economic objectives (DPIRD 2021). These are applied within the constraints of meeting objectives for ecological sustainability, and while having regard to the objectives of other sectors. Performance against socio-economic objectives is currently measured for the commercial sector as the percentage of effort entitlement used, and for charter and recreational fishers as participation relative to historical levels (Table 2.3).

Due to the need for additional management action to recover the WCDSR, there is a high level of risk to these social values and economic returns.

Table 2.3. Performance statistics (% entitlement used, participation) relating to the current socio-economic objectives for the WCDSR.

Sector	Previous season	Current season	Further description
Commercial (WCDSIMF)	2023: 66% entitlement consumed	2024: 68% entitlement consumed	Below target (75% entitlement consumed)
Charter	WCB, 2022-23: 25,290 client days	WCB, 2023-24: 25,307 client days	Between between target and upper threshold (27,901 and 33,481 client days, respectively)
Recreational	WCB, 2020-21: 546,000 line fishing hours	WCB, 2023-24: 386,000 line fishing hours	Reference levels to be reviewed, with previous measure based on hours fished (not line fishing hours)

3 Species Assessment

3.1 Snapper – North WCB

3.1.1 Catch

Most Snapper catches in the northern WCB (Kalbarri and Mid-West areas) have been retained by the commercial sector, with catches fluctuating markedly between years as a result of the variable recruitment of this species (Figure 3.1). Available data since 1975 show a peak in annual commercial Snapper catches above 500 t in 1988, followed by subsequent lower peaks occurring at an approximately decadal interval (Figure 3.1).

Commercial Snapper catches were substantially reduced in 2015 after reductions in WCDSIMF entitlement in the Kalbarri and Mid-West areas, before increasing steadily to 130 t in 2024 (Figure 3.1). Catches collectively retained by boat-based private recreational and charter fishers in the northern WCB increased from ~ 20 t to 30 t, before reducing back to 20 t since 2023 (Figure 3.1; Ryan et al. 2022; 2025). The total retained catch of Snapper in the northern WCB in 2024 was 149 t, of which 88% was retained by the commercial sector.

Data from commercial (WCDSIMF and TDGDLF) and charter logbooks indicate low spatial overlap in catches of Snapper in the northern WCB by these sectors (Figure 3.2). Between 2018 and 2022 there was a relatively wide spread of 10×10 nm blocks with high average Snapper catches by WCDSIMF operators, primarily focused to the north and south of the Houtman Abrolhos Islands (Figure 3.2). In contrast, the Snapper catches by the TDGDLF were lower and taken closer to shore. Charter catches of Snapper in the northern WCB have mostly been landed off Kalbarri, around the Abrolhos Islands and off Jurien Bay (Figure 3.2).

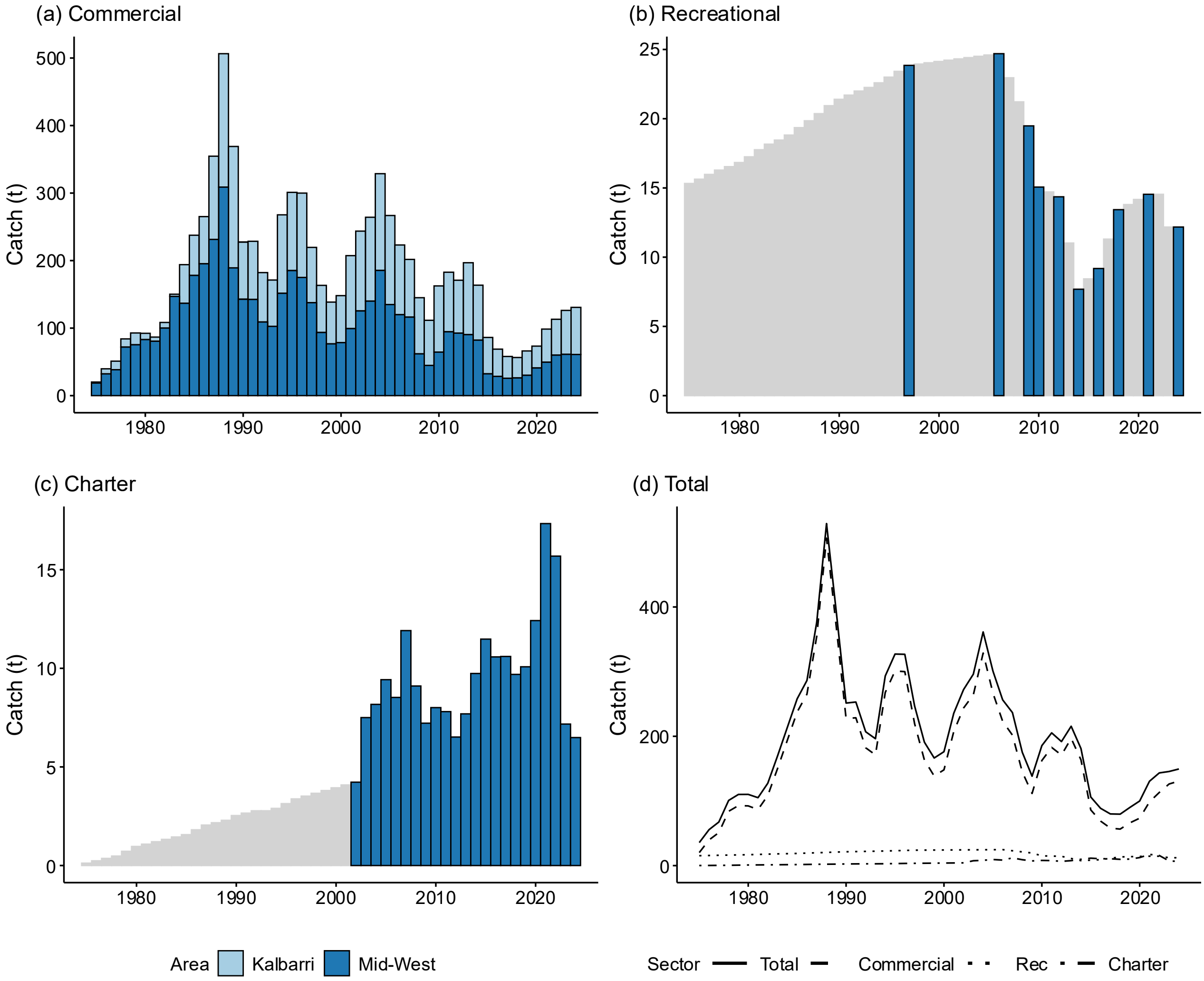


Figure 3.1. Retained catches of Snapper by (a) commercial, (b) recreational and (c) charter fishers in the northern WCB since 1975, noting that Kalbarri and Mid-West data are combined for recreational and charter fishers. (d) Time series of total estimated retained catches in the northern WCB by each sector. The grey bars in the recreational and charter catch plots represent reconstructed catches in years without data, where historical values have been based on changes in population growth and numbers of charter operators, respectively.

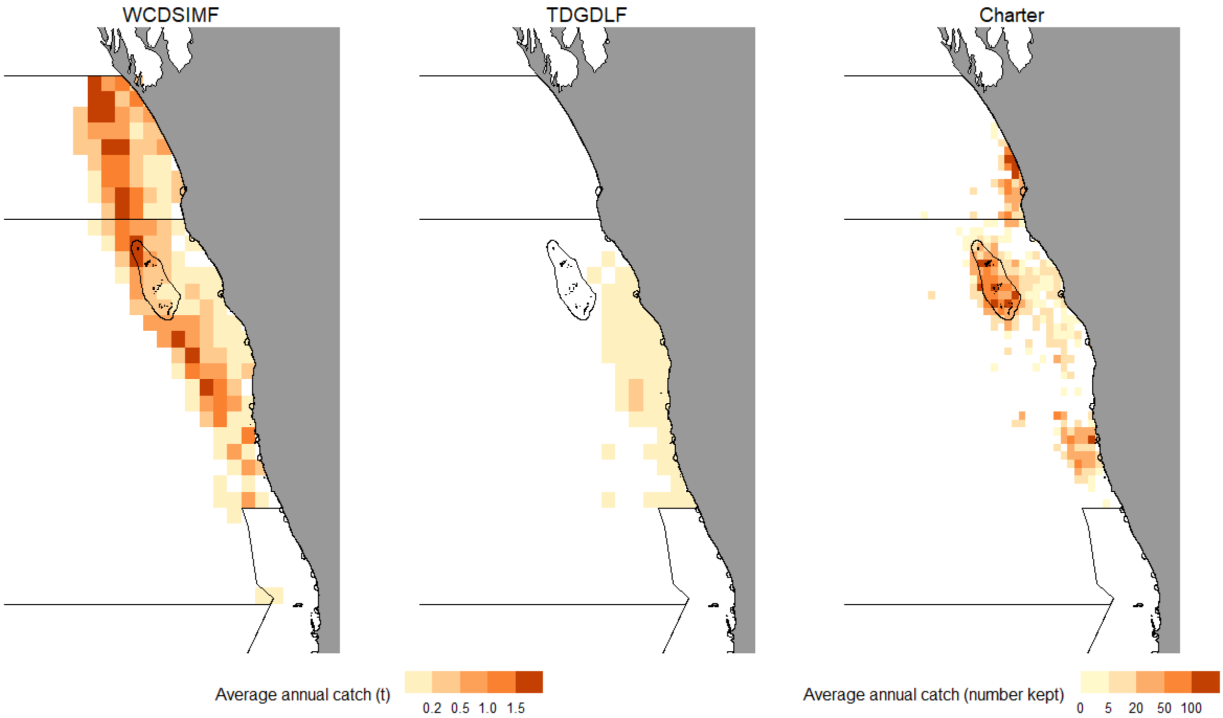


Figure 3.2. Typical distribution of catches of Snapper in the northern WCB based on average annual retained catches (2018–2022) across spatial reporting blocks for the WCDSIMF and TDGDLF (10×10 nm blocks) and charter fishers (5×5 nm blocks). Note the differing scales of plots, with commercial catch reported as weight and charter catch as numbers of fish.

3.1.2 Catch Per Unit Effort

Annual standardised commercial catch per unit effort (CPUE) for Snapper in the northern WCB, adjusted to account for assumed changes in fishing efficiency, have been calculated separately for handline and dropline fishing reported in monthly and daily logbooks. Adjusted CPUE derived from monthly logbooks show overall declining trends from the mid-1980s, except for short periods of increasing CPUE in the mid-1990s and mid-2000s (Figure 3.3), indicative of strong recruitment pulses entering the fishery.

Based on more recent information from daily logbooks in place since 2008, commercial dropline CPUE remained relatively stable until 2020, followed by an increasing trend in recent years (Figure 3.3). The handline CPUE based on daily logbook data suggests more fluctuating stock levels since 2008, with a decrease observed between 2013 and 2016, followed by a marked increase since 2020 (Figure 3.3).

Daily dropline and handline CPUE time series for Snapper in the northern WCB both indicate a recent increase in stock levels. This trend is consistent with that recently observed for Snapper in oceanic waters of the Gascoyne Coast Bioregion, which comprises the same genetic stock, and is indicative of increasing abundance driven by recent above-average recruitment.

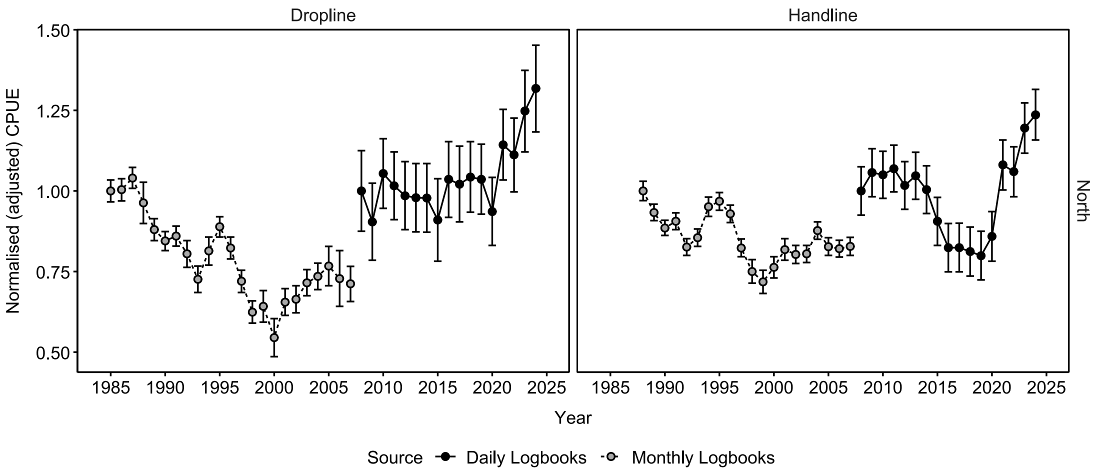


Figure 3.3. Commercial dropline and handline catch per unit effort (CPUE ±95% CI; standardised and adjusted for assumed changes in fishing efficiency) for Snapper in the northern (Kalbarri and Mid-West) management areas of the WCB, based on data from monthly (grey points, dashed lines) and daily (black points, solid lines) logbooks. Note that each time series has been normalised to start at 1.

3.1.3 Length Compositions

Annual length composition data for Snapper in the northern WCB show an increase in the lengths of legal-sized individuals (≥ 410 mm) caught by commercial, recreational and charter fishers from around 2010 to 2015 (Figure 3.4), indicative of a strong cohort recruiting into the fishery and growing larger over this period. Median lengths of Snapper retained by each sector increased from ~ 500 mm in 2010 to ~ 550-600 mm in 2015, after which they returned to values similar to years prior to 2010 (Figure 3.4).

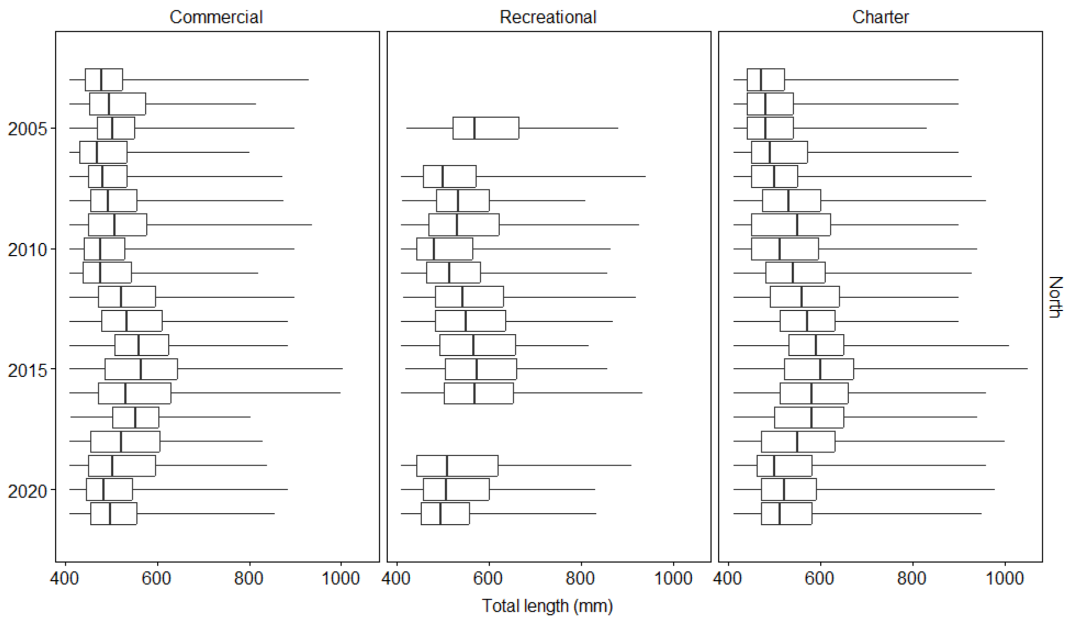


Figure 3.4. Length distributions of Snapper caught by commercial, recreational and charter fishers in the northern (Kalbarri and Mid-West) management areas of the WCB, grouped by biological years (e.g., 2020 is 1 Aug 2020–31 Jul 2021). The boxes show the 25th, 50th (median) and 75th percentiles of observed lengths, with the horizontal lines extending between the minimum and maximum observed values. Only data from years with sample sizes above 100 fish are shown.

3.1.4 Age Compositions

Age data for Snapper sampled from commercial and recreational catches in the Kalbarri and Mid-West management areas show that individuals are first retained by fishers at ~ 3 years old (Figure 3.5). There is some indication in the data of recent strong recruitment from cohorts spawned around 2015-16, which have comprised a large component of retained catches in the last sampling period (Figure 3.5). The limited number of Snapper > 10 years old in samples across all years, and relatively stable mean age (Figure 3.6), suggests that fishing pressure since at least the early 2000s has been too high to allow cohorts to persist for more than just a few years, despite the fact that this species can live for several decades.

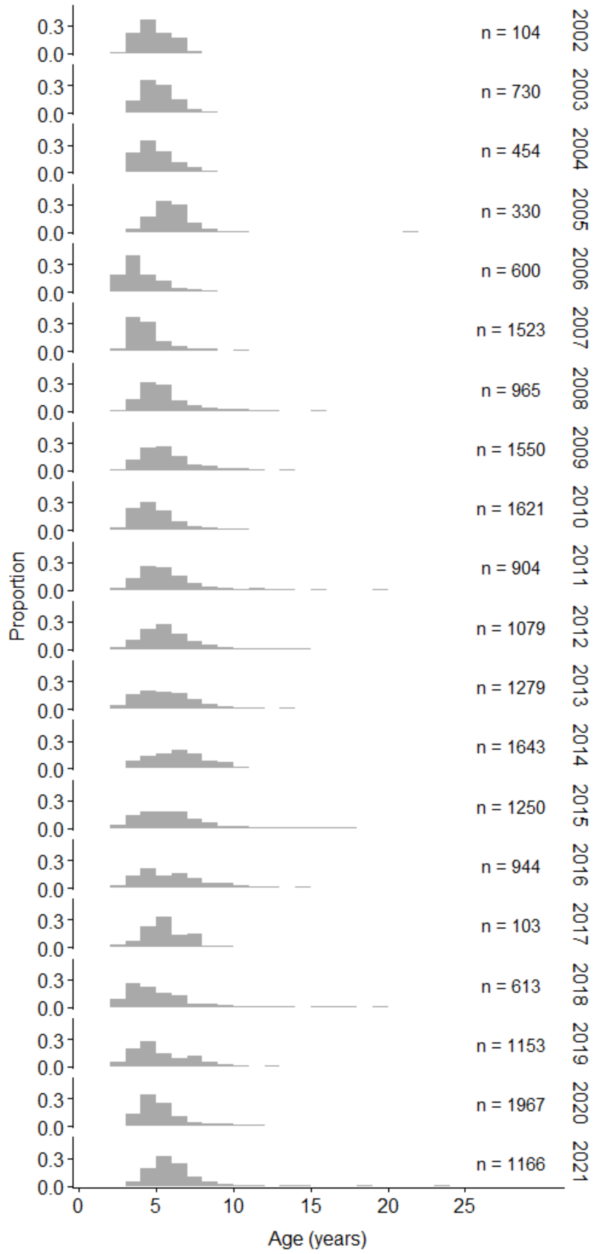


Figure 3.5. Relative age frequencies of Snapper sampled from commercial and recreational catches (data from the two sectors combined) in the northern (Kalbarri and Mid-West) management areas of the WCB, grouped by biological years (e.g. 2020 is 1 Aug 2020–31 Jul 2021). Note only age frequency distributions from years with sample sizes above 100 fish are presented.

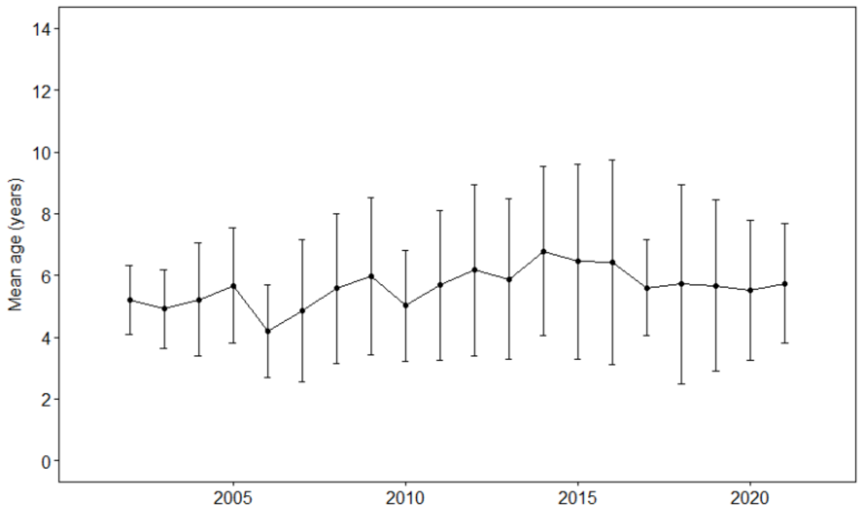


Figure 3.6. Mean age (±SD) of Snapper sampled from commercial and recreational catches in the northern (Kalbarri and Mid-West) management areas of the WCB, grouped by biological years (e.g. 2020 is 1 Aug 2020–31 Jul 2021).

3.1.5 Environmental Impacts

Recruitment success of demersal species varies markedly between years, influenced in part by environmental factors. As the spawning of Snapper is closely linked to temperature (peaking during winter months in the northern WCB as temperatures cool to ~ 19-21°C), projected increases in water temperatures and more frequent marine heatwaves have the potential to affect the recruitment of this species. At the northern edge of the stock's distribution in the Gascoyne, recent strong cohorts have been spawned during years of cooler winter temperatures. Projections of a weaker Leeuwin Current and increase in El Nino events could reduce southward dispersal of eggs and larvae from the Gascoyne during winter spawning. Based on their biological attributes, Snapper in the northern WCB have a medium sensitivity to climate change.

3.1.6 Model Assessment

3.1.6.1 Level 3 Assessment

Estimates of the long-term average *F* of fully selected Snapper in the northern (Kalbarri and Mid-West) management areas of the WCB, derived by fitting an age-based catch curve model that accounts for recruitment variability to age composition data collected from commercial and recreational catches between 2018 and 2022 (see Appendix 2 for model fit), were at or above the limit reference level of 0.21 y^{-1} (corresponding to 1.5 times the value of natural mortality, *M*, of 0.14 y^{-1} for this stock) (Table 3.1). Estimates of *F* based on samples from catches in Kalbarri and Mid-West have increased slightly from the previous sampling period.

Estimates of female B_{rel}, as a measure of population reproductive output, were derived from a per-recruit model that incorporates a Beverton-Holt stock-recruitment relationship (with steepness set to 0.75) and age-based gear selectivity and retention curves to account for the PRM of released undersized fish (considered to be 25% for Snapper, see Appendix 2 for model diagnostics). The estimated B_{rel} for female Snapper in the northern WCB, based on catch curve estimates of *F* from all commercial and recreational samples collected in the Kalbarri and Mid-West areas in 2018-21, was 0.13 (i.e., below the limit reference level of 0.2) (Table 3.1).

Table 3.1. Catch curve estimates of long-term average F (y_{-1}, ±95% CI) and per-recruit estimates of female relative spawning biomass (B_{rel} ±95% CI) for Snapper based on age composition data collected from commercial and recreational catches in the northern management areas of the WCB in 2018-22. Point estimates were compared to reference levels, where red denotes $F \geq$ limit level of 1.5M (0.21 y^{-1}) or $B_{rel} \leq$ limit level of 0.2.

Area	F (±95% CI)	Female B_{rel} (±95% CI)
North	0.26 (0.24-0.28)	0.13 (0.09-0.17)
Kalbarri	0.33 (0.28-0.38)	0.08 (0.05-0.12)
Mid-West	0.26 (0.23-0.28)	0.14 (0.10-0.18)

3.1.6.2 Level 5 Assessment

An age-based integrated assessment model (see Appendix 1), incorporating separate gear selectivity and retention curves to account for the PRM of released undersized fish (assumed to be 25% for Snapper), was fitted to annual catch, standardised commercial CPUE and age composition data for Snapper in the northern WCB (Kalbarri and Mid-West management areas) up to 2024 (inclusive).

The estimated female B_{rel} has increased to 0.17 (95% CI = 0.14–0.21) in 2024 but remains below the limit reference level of 0.2. Recent above-average recruitment of Snapper spawned between 2015 and 2017 has coincided with marked increases in retained catches and commercial CPUE, with the estimated F in 2024 of 0.14 y^{-1} (95% CI = 0.10–0.18 y^{-1}) above the estimated F_{MSY} of 0.12 y^{-1} (Figure 3.7) and around the estimated value of M (0.14 y^{-1}) for this stock.

Model projections assuming average future recruitment levels suggest that B_{rel} for the Snapper stock in the northern WCB is unlikely to rebuild above the threshold reference level of B_{MSY} by 2030, even if catches are reduced to the current recovery benchmark. Although highly uncertain, projections suggest that recovery to the target level may not occur until 2035-2040 unless current catches are substantially reduced.

A preliminary exploration was undertaken in this assessment to estimate stock status based on an alternative measure for population reproductive output (relative fecundity, E_{rel}). This alternative measure accounts for the disproportionately greater contribution to population egg production (fecundity) now understood to be made by large mature female fish compared to smaller mature females (Evans-Powell et al. 2024). These early results suggest that E_{rel} was lower than B_{rel} in 2024 (i.e., 0.12 *vs* 0.17), indicating poorer stock status at this time.

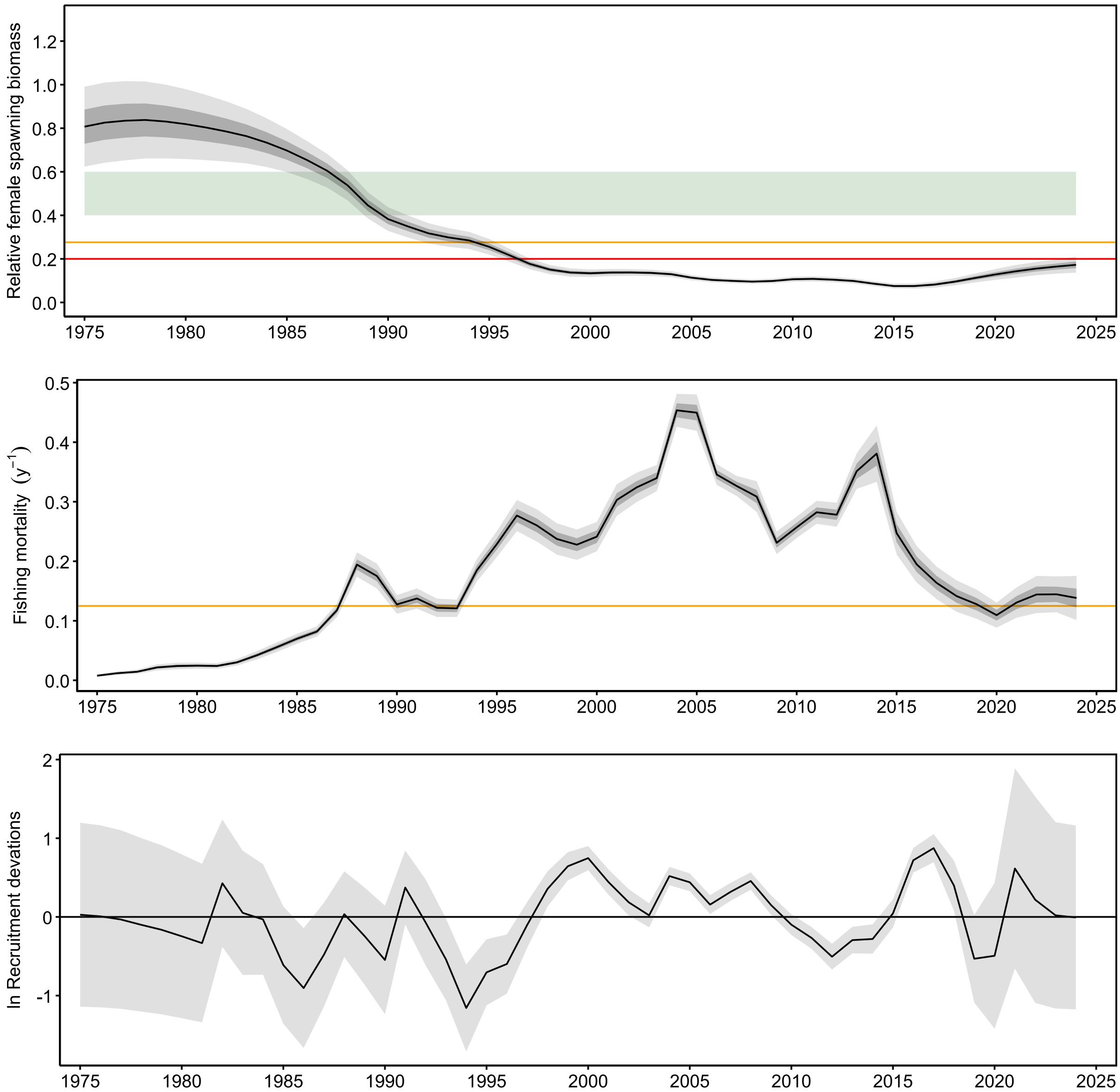


Figure 3.7. (Top) Estimates of annual relative female spawning biomass (B_{rel}) for the Snapper stock in the northern WCB (Kalbarri and Mid-West management areas), compared to the target (green range), threshold (orange line, B_{MSY}) and limit (red line) reference levels. (Middle) Estimates of annual fishing mortality (F, y^{-1}) for the Snapper stock in the northern WCB, compared to the estimated F_{MSY}. (Bottom) Estimated annual recruitment deviations of 1 year old Snapper in the northern WCB. The dark and light shaded areas around each line represent the 60% and 95% CIs, respectively, around estimated model parameters.

3.1.7 Risk-based Weight of Evidence Assessment

Category	Line of Evidence
Catch	Annual retained catches of Snapper in the northern WCB have reduced since a peak in the late 1980s but fluctuate markedly because of variable recruitment. The total retained catch of Snapper in the northern WCB in 2024 was 149 t, of which 88% was landed by the commercial sector.
Level 1 Assessment The continued decadal fluctuations in catches since the start of the recovery period, driven by a large variability in annual recruitment, indicate that the stock has continued experiencing overfishing.	
CPUE	Commercial dropline CPUE has remained relatively constant over time, while handline CPUE shows more marked fluctuations in abundance driven by variability in recruitment. Following a period of decreasing handline CPUE after the last recruitment pulse, the index since 2019 shows a marked gradual increase.
Level 2 Assessment The recent increasing CPUE trend indicates an increase in stock abundance, likely driven by a strong pulse of recruitment.	
Length Composition	Snapper retained by recreational and charter fishers in the northern WCB have mostly ranged between 450 and 600 mm. The median lengths of Snapper retained by fishers in the northern WCB fluctuate over time because of variability in the recruitment.
Age Composition	The limited number of Snapper >10 years old sampled since 2002 indicates that fishing pressure has been too high to allow cohorts to persist in the fishery for more than a few years. There is some indication from the data of recent above-average recruitment from cohorts spawned around 2015-16.
Equilibrium Biomass Model	Based on age composition data from 2018-22, catch curve estimates of the long-term average *F* of fully-selected Snapper in the northern (Kalbarri and Mid-West) management areas increased slightly from the previous sampling period and remain above the limit reference level of 0.21 y^{-1} (corresponding to 1.5 times the value of natural mortality of 0.14 y^{-1} for this stock). Estimates of B_{rel} derived from an equilibrium biomass model that incorporates a Beverton-Holt stock-recruitment relationship to account for the potential effect of fishing on recruitment was 0.13 (i.e., below the limit reference level of 0.2).

Level 3 Assessment Consistent with the lack of old fish in age compositions and continued high catches dominated by recent strong recruitment pulses, equilibrium (Level 3) model estimates of *F* and B_{rel} suggest that overfishing is still occurring and the stock remains depleted. However, these results should be interpreted with caution due to the equilibrium assumptions of the models used.	
Integrated Model	The integrated model estimate of *F* for Snapper in the northern WCB in 2024 was at the threshold reference level corresponding to the value of natural mortality (0.14 y^{-1}). The estimated B_{rel} in 2024 of 0.17 (95% CI = 0.14-0.21) remains below the limit reference level of 0.2, with model projections suggesting that the stock is unlikely to rebuild to the threshold level of 0.3 (B_{MSY}) by 2030 even if catches are reduced to the current recovery benchmark.
Level 5 Assessment Integrated (Level 5) model outputs demonstrate that the stock remains overfished and the current level of fishing mortality is not allowing the stock to rebuild at an acceptable rate.	
Environmental Impact	Warming water temperatures have the potential to affect spawning and recruitment of Snapper, particularly at the northern extent of its range. Based on their biological attributes, Snapper in the northern WCB have a medium sensitivity to climate change.
Risk Assessment C1 Minor (Above Target): The likelihood of minor depletion is assessed as Remote (<5%). C2 Moderate (Above Threshold, below Target): The likelihood of moderate depletion is assessed as Remote (<5%). C3 High (Above Limit, below Threshold): The likelihood of high depletion is assessed as Remote, with an estimated probability of <5% that B_{rel} of Snapper in the northern WCB was between the threshold and limit reference levels of 0.3 (B_{MSY}) and 0.2, respectively, in 2024. C4 Major (Below Limit): The likelihood of major depletion is assessed as Likely, with an estimated probability of >95% that B_{rel} of Snapper in the northern WCB was below the limit reference level of 0.2 in 2024. Based on the risk matrix below, the overall risk to the Snapper stock in the northern WCB is assessed as **Severe** (C4 × L4).	

Consequence (Stock level)	Likelihood			
	1 Remote (<5%)	2 Unlikely (5-20%)	3 Possible (20-50%)	4 Likely (>50%)
1 Minor (above Target)	X			
2 Moderate (between Target and Threshold)	X			
3 High (between Threshold and Limit)	X			
4 Major (below Limit)				Severe

3.1.8 Assessment Advice

The integrated model assessment of the Snapper stock in the northern WCB shows that Step 1 of the recovery plan, aiming to rebuild biomass above the limit level of 0.2 by 2020, has not been met. Model projections indicate that the stock is unlikely to recover to the threshold level of 0.3 by 2030 (Step 2) even if current catches are substantially reduced.

3.2 Snapper – South WCB

3.2.1 Catch

Retained Snapper catches in the southern WCB (Metropolitan and South-West areas) have been much lower than those from the northern WCB stock. Annual commercial catches peaked above 60 t in the mid-2000s, followed by a large reduction in catch after the Metropolitan area closure to WCDSIMF and TDGDLF fishers in 2007 (Figure 3.8).

Since 2010, annual commercial Snapper catches in the southern WCB (primarily taken in the South-West management area) remained relatively stable at ~ 10 t before increasing to 16 t in 2024 (Figure 3.8). Data show reduced catches of Snapper retained by recreational and charter fishers after the implementation of new management measures to recover the WCDSR in 2010, followed by a gradual increase back to above pre-management catch levels (Figure 3.8). The total retained catch of Snapper in the southern WCB was 57 t in 2024, of which 71% was landed by recreational and charter fishers.

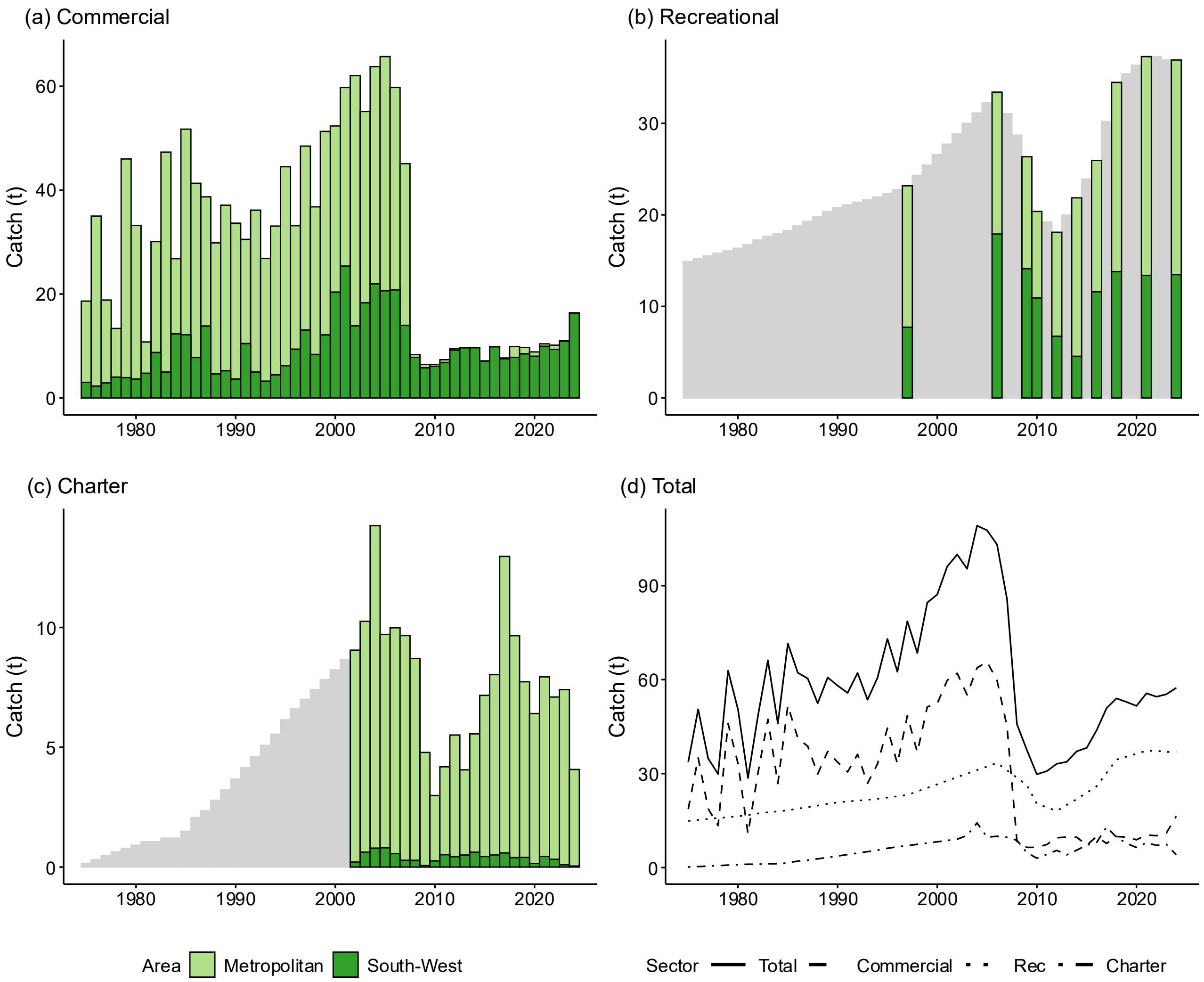


Figure 3.8. Retained catches of Snapper by (a) commercial, (b) recreational and (c) charter fishers in the southern (Metropolitan and South-West) areas of the WCB since 1975. (d) Time series of total estimated retained catches in the southern WCB by each sector. The grey bars in the recreational and charter catch plots represent reconstructed catches in years without data, where historical values have been based on changes in population growth and numbers of charter operators.

Commercial logbook data from 2018 to 2022 show Snapper catches by WCDSIMF in the South-West management area of the WCB have been highest within 10×10 nm reporting blocks off Cape Naturaliste, while TDGDLF caches of this species have primarily been taken in Geographe Bay and off Augusta in the south (Figure 3.9). Snapper have mostly been taken by charter fishers in the Metropolitan management area, with the 5×5 nm reporting blocks with the highest catches located around Rottnest Island and off Lancelin (Figure 3.9).

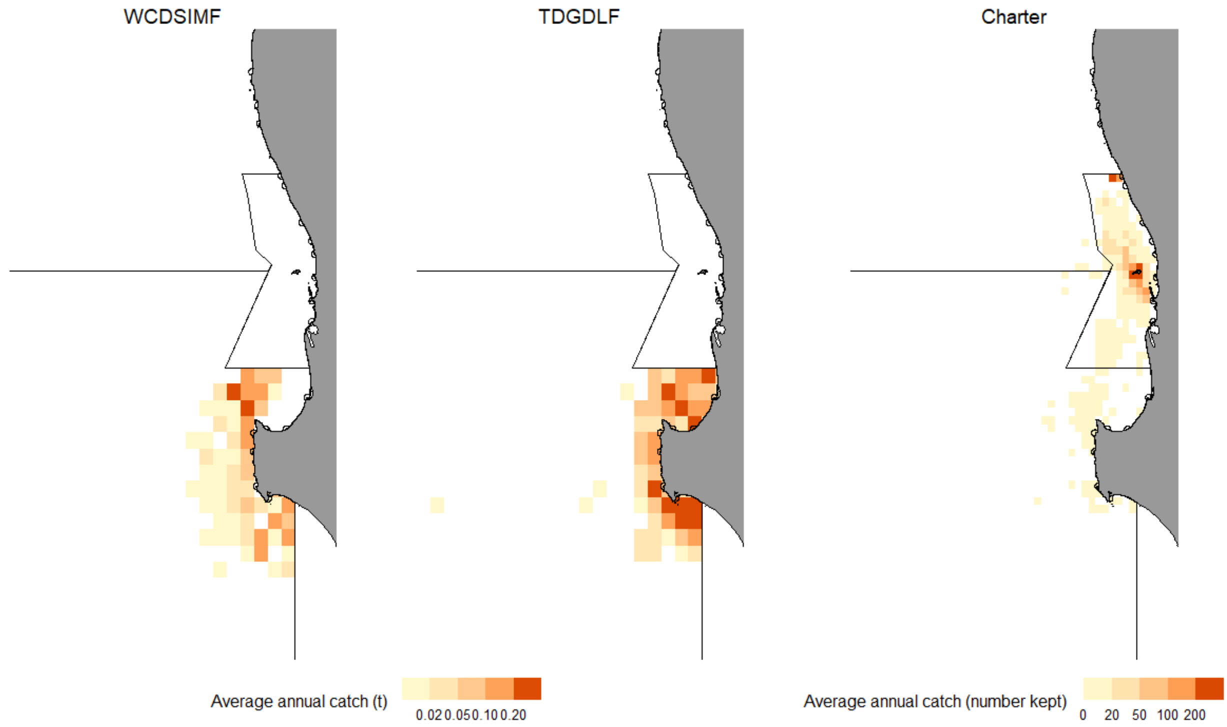


Figure 3.9. Typical distribution of catches of Snapper in the southern WCB based on average annual retained catches (2018–2022) across spatial reporting blocks for the WCDSIMF and TDGDLF (10×10 nm blocks) and charter fishers (5×5 nm blocks). Note the differing scales of plots, with commercial catch reported as weight and charter catch as numbers of fish.

3.2.2 Catch Per Unit Effort

Annual commercial standardised CPUE for Snapper in the southern WCB, adjusted to account for assumed changes in fishing efficiency, have been calculated separately for handline and dropline fishing reported in monthly returns prior to 2008. The CPUE calculated from daily logbook data in place since 2008 are uncertain for Snapper in the southern WCB because of the limited commercial catches of this species in the South-West management area.

The time series of adjusted dropline CPUE from monthly logbooks show an overall declining trend from the mid-1980s to early 2000s (Figure 3.10). In contrast, the time series of handline CPUE shows greater fluctuations over this period, but with the first and last data points being at similar levels (Figure 3.10). As this is inconsistent with early age-based assessments suggesting declining stock levels around this time, only the dropline CPUE is currently included in the model assessment for this stock.

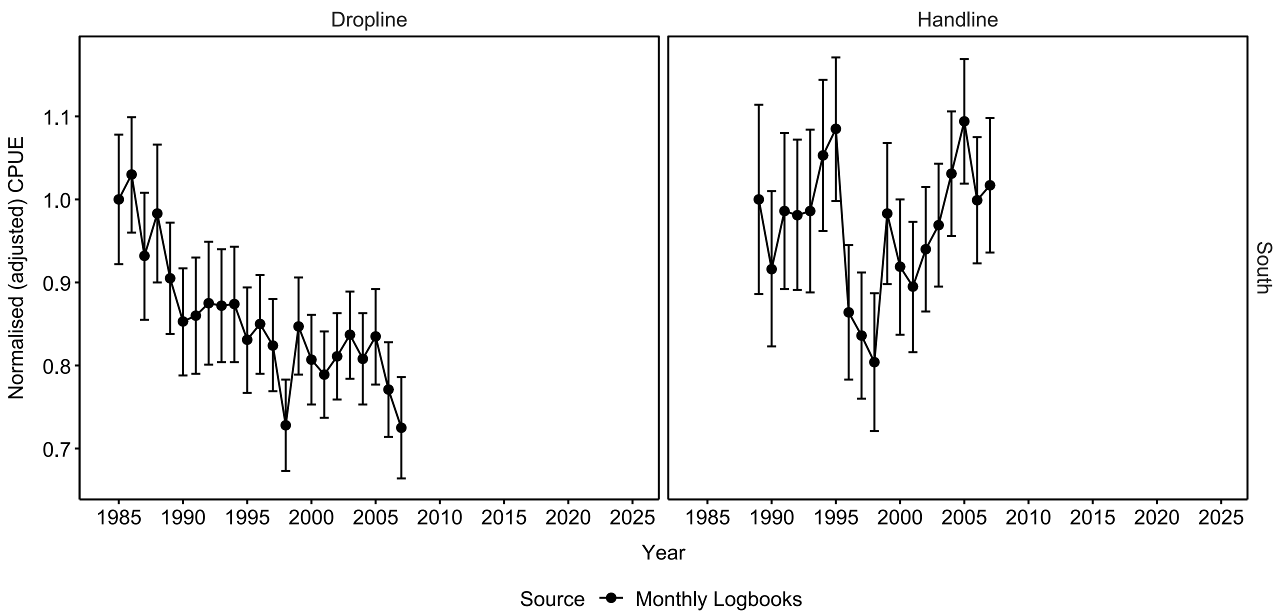


Figure 3.10. Commercial dropline and handline catch per unit effort (CPUE ±95% CI; standardised and adjusted for assumed changes in fishing efficiency) of Snapper in the southern WCB, based on data from monthly logbooks. Note that each time series has been normalised to start at 1. There is no daily logbook CPUE index for this stock due to the low commercial Snapper catches in this region since the closure of the Metropolitan management area in 2007.

3.2.3 Length Compositions

Annual length composition data for Snapper in the southern WCB show an increase in the lengths of individuals caught by boat-based recreational and charter fishers in 2009-10, when the MLL was increased from 410 to 500 mm (Figure 3.11). Following this change, Snapper retained by recreational and charter fishers have mostly ranged between 550 and 750 mm (Figure 3.11). Data from charter logbooks show an increase in the median lengths of Snapper from around 2013 to 2018, likely associated with good recruitment into the fishery, followed by a decline influenced by fishing mortality (Figure 3.11).

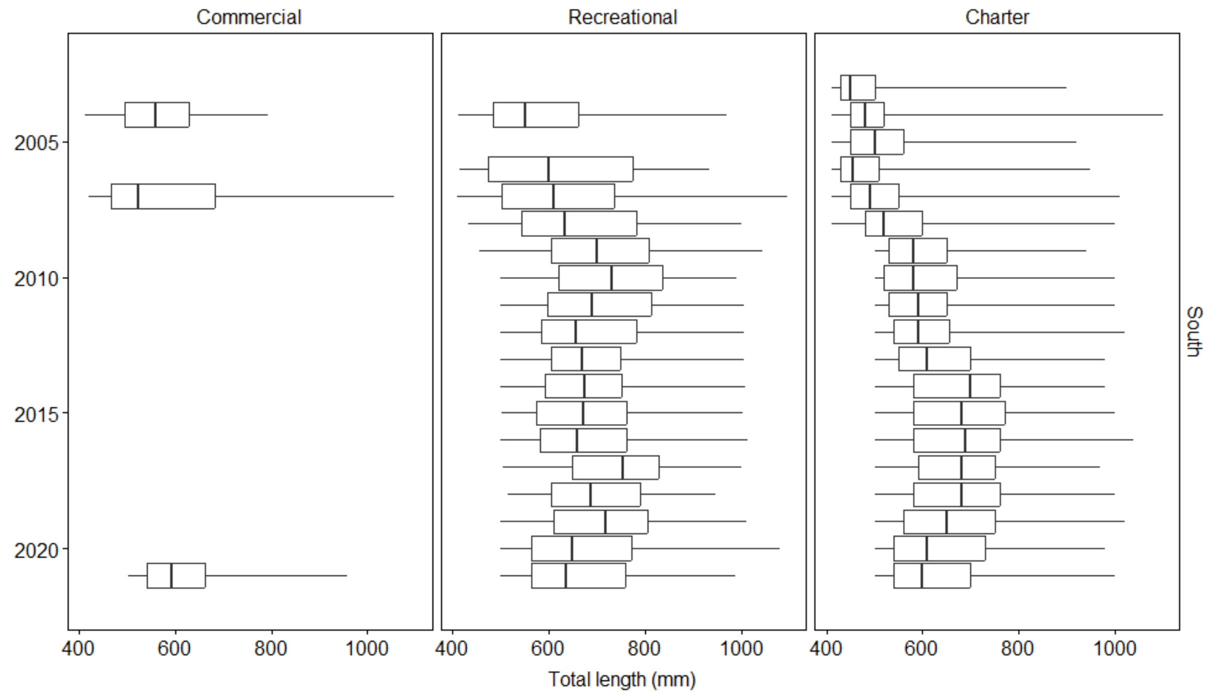


Figure 3.11. Length distributions of Snapper caught by commercial, recreational and charter fishers in the southern (Metropolitan and South-West) management areas of the WCB, grouped by biological years (e.g. 2020 is 1 Nov 2020–31 Oct 2021). Note that the MLL changed from 410 mm to 450 mm in 2009, and 500 mm in 2010. The boxes represent the 25th, 50th (median) and 75th percentile of observed lengths, with the horizontal lines extending between the minimum and maximum observed values. Only data from years with sample sizes above 100 fish are shown.

3.2.4 Age Compositions

Age data for Snapper sampled annually from recreational catches in the Metropolitan and South-West areas show that individuals are first retained by fishers at ~ 3-4 years old (Figure 3.12). The relative age frequencies indicate high interannual variability in recruitment, with relatively high numbers of fish belonging to cohorts spawned in 1999 and 2007 still present in samples collected in 2020 (Figure 3.12). Recent age data indicate relatively strong recruitment to this stock from cohorts spawned in 2010 and 2015 (Figure 3.12), which is consistent with a slight increase in the mean age of sampled fish over time (Figure 3.13). The vast majority of Snapper sampled in recent years were < 15 years old, with very few fish were aged above 20 years (Figure 3.12).

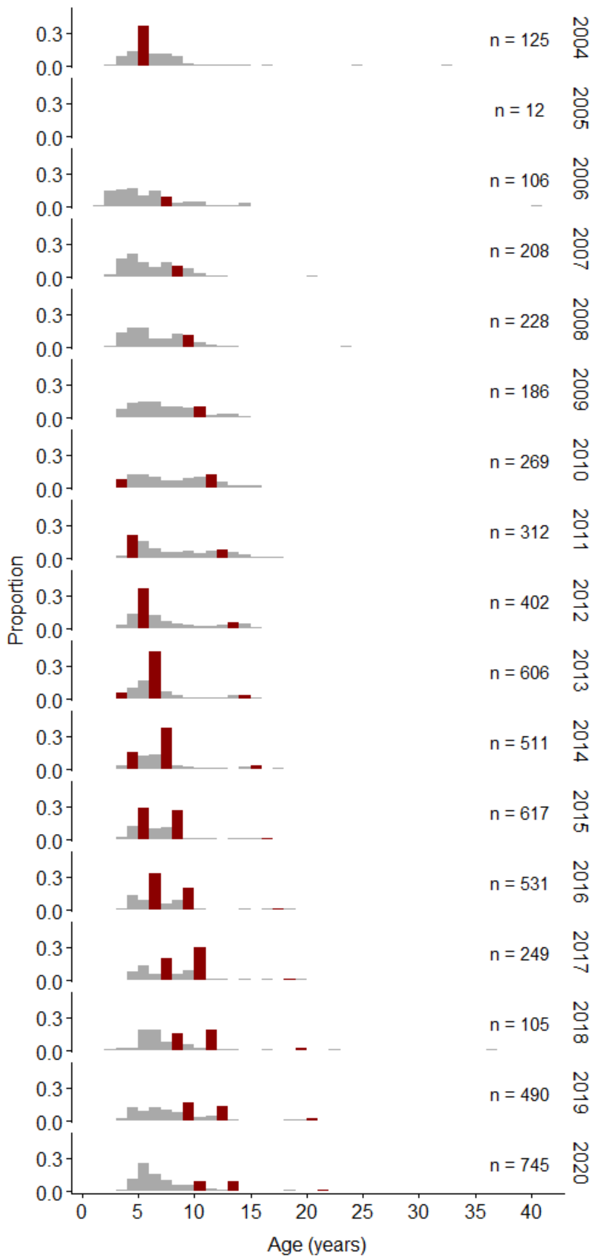


Figure 3.12. Relative age frequencies of Snapper sampled from recreational catches in the southern (Metropolitan and South-West) management areas of the WCB, grouped by biological years (e.g. 2020 is 1 Nov 2020–31 Oct 2021). Note only data from years with sample sizes above 100 fish are presented. Cohorts spawned in 1999, 2007 and 2010 are shown in red.

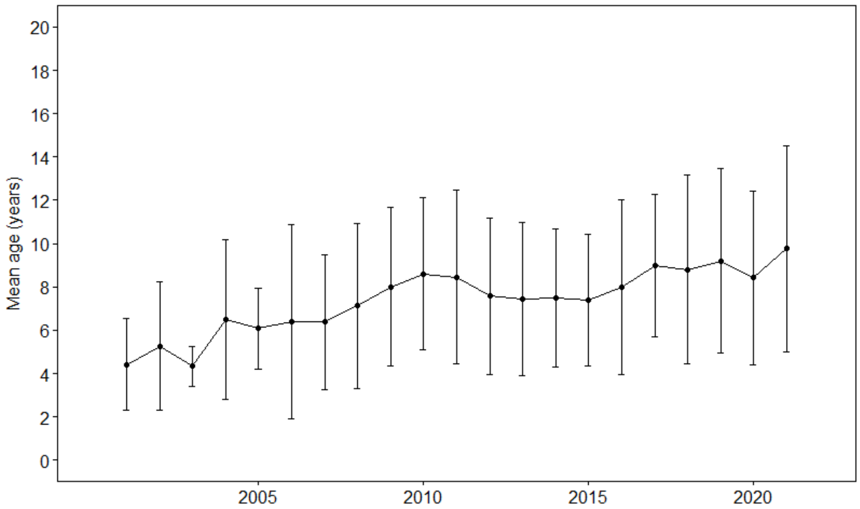


Figure 3.13. Mean age (±SD) of Snapper sampled from recreational catches in the southern (Metropolitan and South-West) management areas of the WCB, by biological years (e.g. 2020 is 1 Nov 2020–31 Oct 2021).

3.2.5 Environmental Impacts

Recruitment success of demersal species varies markedly between years, influenced in part by environmental factors. As the spawning of Snapper is closely linked to temperature (peaking during spring/summer months in the southern WCB as temperatures warm to 19-21°C), warming waters and more frequent marine heatwaves have the potential to affect the spawning period and recruitment of this species. Although projections of a weaker Leeuwin Current and increase El Nino events may affect dispersal of eggs and larvae during spring/summer spawning, the overall impact on the broader stock is likely limited. Reduced rainfall may negatively influence primary productivity and larval prey in nearshore nursery areas. Based on their biological attributes, Snapper in the southern WCB have a medium sensitivity to climate change.

3.2.6 Model Assessment

3.2.6.1 Level 3 Assessment

The estimated long-term average *F* for fully-selected Snapper in the southern (Metropolitan and South-West) areas of the WCB, derived by fitting an age-based catch curve model that accounts for recruitment variability to age composition data collected between 2018 and 2022 (see Appendix 2 for model fit), was between the threshold and limit reference levels of 0.12 y^{-1} (*M*) and 0.18 y^{-1} (1.5*M*), respectively, for this stock (Table 3.2). The estimated *F* based on samples from recreational catches from the South-West management area (0.12 y^{-1}, i.e., at the threshold level) was much lower than that based on recreational samples from the Metropolitan area (0.23 y^{-1}; Table 3.2), with both remaining relatively stable over time.

The estimated female B_{rel} for Snapper in the southern WCB in 2018-22, derived from a per-recruit model that incorporates a Beverton-Holt stock-recruitment relationship (with steepness set to 0.75) and accounts for the PRM (25%) of released undersized fish (see Appendix 2 for model diagnostics), was between the threshold and limit reference levels of 0.3 and 0.2, respectively (Table 3.2). While the estimated B_{rel} for the South-West management area (0.28) was close to the threshold level, the corresponding estimate of B_{rel} for the Metropolitan area (0.11) was below the limit level (Table 3.2).

Table 3.2. Catch curve estimates of long-term average F (y^{-1}, ±95% CI) and per-recruit estimates of female relative spawning biomass (B_{rel} ± 95% CI) for Snapper based on age composition data collected from recreational catches in the southern management areas of the WCB in 2018-22. Point estimates were compared to reference levels, where orange denotes F between the threshold and limit levels of M and 1.5M (0.12 and 0.18 y^{-1}, respectively) or B_{rel} between the threshold and limit levels of 0.3 and 0.2, respectively, and red denotes $F \geq$ limit level or $B_{rel} \leq$ limit level.

Area	F (±95% CI)	Female B_{rel} (±95% CI)
South	0.15 (0.13-0.18)	0.21 (0.16-0.25)
Metropolitan	0.23 (0.18-0.29)	0.11 (0.07-0.14)
South-West	0.12 (0.10-0.14)	0.28 (0.24-0.33)

3.2.6.2 Level 5 Assessment

The integrated Snapper assessment model (see Appendix 1), which accounts for the PRM of undersized fish (assumed to be 25% for Snapper), was fitted to annual catch, CPUE (only available from monthly returns) and age composition data for the southern WCB (Metropolitan and South-West management areas) up to 2024 (inclusive).

Female B_{rel} of Snapper in the southern WCB in 2024 was estimated to be at the limit reference level of 0.2 (noting large 95% CI of 0.02–0.39, due to the lack of a commercial CPUE time series from daily logbooks since 2008), indicating limited change in stock levels since the last assessment (Figure 3.14). While recent estimates of F were also highly uncertain, the 2024 estimate of 0.15 y^{-1} (95% CI = 0.00–0.30 y^{-1}) was above the estimated F_{MSY} of 0.12 y^{-1} and M for this stock (Figure 3.14) and suggests a continued high level of fishing pressure on the stock (relative to that required for rebuilding), resulting from recent high catches. Although there is uncertainty in the model estimates for 2024, F remaining above F_{MSY} would not be expected to have allowed substantial increase in the number of older fish in the population since 2022 and therefore improvement in stock status.

Model projections for Snapper in the southern WCB, assuming average future recruitment levels, show that B_{rel} is unlikely to rebuild above the threshold reference level of B_{MSY} by 2030 even if catches are reduced to the current recovery benchmark. Due to the substantial uncertainty around Snapper model outputs for the southern WCB compared to those for the northern WCB, projections suggest that recovery to the target level may not occur until 2040 unless current catches are substantially reduced.

A preliminary exploration undertaken in this assessment to estimate stock status based on an alternative measure for population reproductive output (relative fecundity, E_{rel}) suggest that this measure in 2024 was lower than B_{rel} (0.13 *vs* 0.2), indicating poorer stock status at this time.

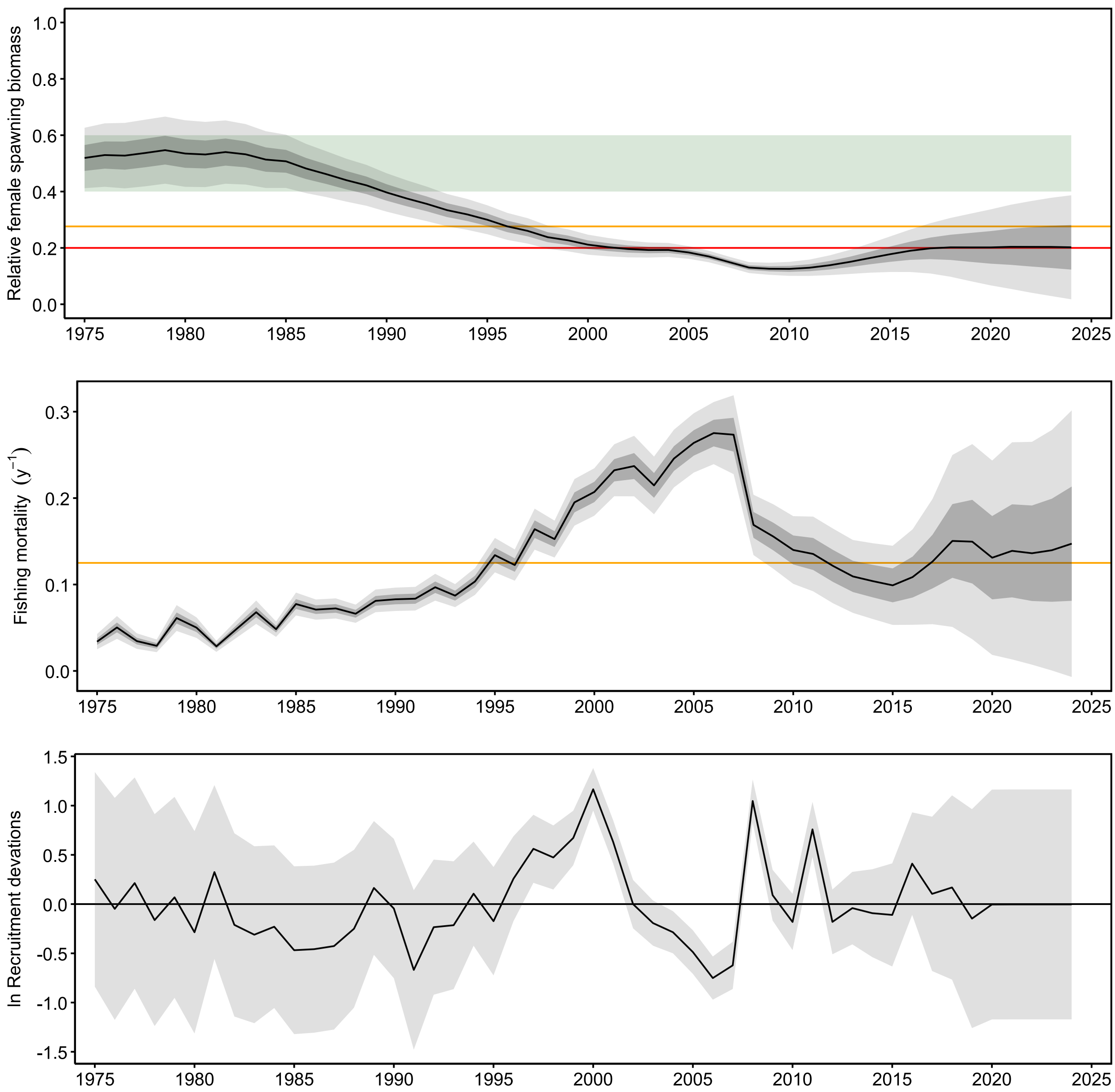


Figure 3.14. (Top) Estimates of annual relative female spawning biomass (B_{rel}) for the Snapper stock in the southern WCB (Metropolitan and South-West management areas), compared to the target (green range), threshold (orange line, B_{MSY}) and limit (red line) reference levels. (Middle) Estimates of annual fishing mortality (F, y^{-1}) for the Snapper stock in the southern WCB, compared to the estimated F_{MSY}. (Bottom) Estimated annual recruitment devations for for 1 year old Snapper in the southern WCB. The dark and light shaded areas around each line represent the 60% and 95% CIs, respectively, around estimated model parameters.

3.2.7 Risk-based Weight of Evidence Assessment

Category	Line of Evidence
Catch	Annual retained catches of Snapper in the southern WCB have reduced markedly since peaking above 100 t in the mid-2000s but shows a recent gradual increase. The total retained catch of Snapper in the southern WCB in 2024 was 57 t, of which 71% was landed by the recreational sector.
Level 1 Assessment A gradual increase in annual catches since the start of the recovery period, likely associated with an increase in stock levels influenced by recruitment pulses, could be leading to continued overfishing.	
Catch Per Unit Effort	Commercial handline CPUE indicate periods of increasing CPUE consistent with patterns observed in the northern WCB, likely driven by recruitment variability. There is limited commercial CPUE data from daily logbooks for the southern Snapper stock due to the low commercial catches landed following the closure of the Metropolitan management area to this sector.
Level 2 Assessment Due to the limited commercial catches since 2008, there is no recent CPUE index to inform changes in stock levels.	
Length Composition	Snapper retained by recreational and charter fishers in the southern WCB have mostly ranged between 550-750 mm. Data from charter logbooks showing a recruitment-driven increase in the median lengths from around 2013 to 2018, followed by a decline influenced by fishing mortality.
Age Composition	Age data show high recruitment variability between years, with higher relative numbers of fish belonging to cohorts spawned in 1999, 2007, 2010 and 2015 sampled in recent years. Despite a slight increase in the mean age of sampled fish over time, the majority were < 15 years old, indicating that fishing pressure on the stock has remained high.
Equilibrium Biomass Model	Based on the estimated long-term average *F* for fully selected Snapper in the southern (Metropolitan and South-West) areas of the WCB in 2018-22 (0.15 y^{-1}), the equilibrium biomass model estimate of female B_{rel} was 0.21 (95% CI = 0.16-0.25), between the threshold and limit reference levels of 0.3 and 0.2, respectively. Area-specific estimates indicate higher stock levels in the South-West management area (B_{rel} ~ threshold) compared to the Metropolitan area (B_{rel} < limit).

Level 3 Assessment Despite an increase in the mean age of sampled fish over time, equilibrium (Level 3) model estimates of *F* and B_{rel} indicate that the stock is still experiencing overfishing, leading to limited recovery to date (particularly in the Metropolitan area). However, these results should be interpreted with caution due to the equilibrium assumptions of the models used.	
Integrated Model	Integrated model estimates of *F* indicate that exploitation of Snapper in the southern WCB has remained too high, with the 2024 estimate of 0.15 y^{-1} above the threshold level reference level of 0.12 y^{-1}. The estimated B_{rel} was at the limit level of 0.2 in 2024 (95% CI = 0.02–0.39), with model projections suggesting that the stock is unlikely to rebuild to the threshold level of 0.3 (B_{MSY}) by 2030 even if catches are reduced to the current recovery benchmark.
Level 5 Assessment Consistent with outputs from the Level 3 assessment, the integrated (Level 5) model estimates of *F* and B_{rel} show that overfishing is still occurring because of recent increases in catch, which is impacting on the ability of the stock to recover at an acceptable rate.	
Environmental Impact	Warming water temperatures have the potential to affect spawning of Snapper, while changes in primary productivity and availability of larval prey are also likely to influence recruitment of this species. Based on their biological attributes, Snapper in the southern WCB have a medium sensitivity to climate change.
Risk Assessment C1 Minor (Above Target): The likelihood of minor depletion is assessed as Remote (<5%). C2 Moderate (Above Threshold, below Target): The likelihood of moderate depletion is assessed as Unlikely, with an estimated probability of <20% that B_{rel} of Snapper in the southern WCB was between the target range of 0.4-0.6 and the threshold reference level of 0.3 (B_{MSY}) in 2024. C3 High (Above Limit, below Threshold): The likelihood of high depletion is assessed as Possible, with an estimated probability of ~ 30% that B_{rel} of Snapper in the southern WCB was between the threshold and limit reference levels of 0.3 (B_{MSY}) and 0.2, respectively, in 2024. C4 Major (Below Limit): The likelihood of major depletion is assessed as Possible, with an estimated probability of 50% that B_{rel} of Snapper in the southern WCB was below the limit reference level of 0.2 in 2024. Based on the risk matrix below, the overall risk to the Snapper stock in the southern WCB is assessed as **Severe** (C4 × L3).	

Consequence (Stock level)	Likelihood			
	1 Remote (<5%)	2 Unlikely (5-20%)	3 Possible (20-50%)	4 Likely (>50%)
1 Minor (above Target)	X			
2 Moderate (between Target and Threshold)		X		
3 High (between Threshold and Limit)			X	
4 Major (below Limit)			Severe	

3.2.8 Assessment Advice

The integrated model assessment of the Snapper stock in the southern WCB indicates that Step 1 of the recovery plan, aiming to rebuild biomass above the limit level of 0.2 by 2020, has not been met. Model projections indicate that the stock is unlikely to recover to the threshold level of 0.3 by 2030 (Step 2) even if current catches are substantially reduced.

3.3 WA Dhufish

3.3.1 Catch

Around 90% of WA Dhufish catches are landed in the WCB, with the remainder primarily taken on the south coast of WA. Annual commercial catches of this species in the WCB fluctuated ~ 200 t from the mid-1980s to mid-2000s, with the majority of these taken in the Mid-West (Figure 3.15). After the introduction of the WCDSIMF in 2008, annual commercial catches of this species decreased substantially and have ranged ~ 50-70 t during the last decade (Figure 3.15).

WA Dhufish catches retained by boat-based private recreational fishers reduced markedly following the implementation of management measures in 2010 to recover the resource before increasing to above 100 t in 2017-18 (Figure 3.15). Private recreational fishers in the WCB retained 90 t of WA Dhufish in 2023-24 (Ryan et al. 2025), down from 108 t in 2020-21 (Ryan et al. 2022). Charter catches of WA Dhufish in the WCB remained relatively stable from the mid-2000s until 2020, fluctuating ~ 10 t annually, before gradually decreasing below 5 t in 2024 (Figure 3.15). The total retained catch of WA Dhufish was 137 t in 2024, of which 69% was collectively retained by recreational and charter fishers.

As a result of the marked reduction in retained catches of WA Dhufish in the Mid-West management area since the mid-2000s and a recent increase in the catches retained in the Metropolitan and South-West areas around 2018-2020 (Figure 3.15), there has been an increased proportion of catches of this species landed in the southern WCB (from ~ 50% in the mid-2000s to ~ 70% in 2024). In 2024, 31%, 30% and 39% of WA Dhufish catches were retained in the North (primarily Mid-West), Metropolitan and South-West management areas, respectively.

Data from WCDSIMF logbooks have indicated a recent reduction in the number of 10×10 nm blocks with recorded WA Dhufish catches in the northern extent of the WCB (Fairclough et al. 2021). On average between 2018 and 2022, the highest WA Dhufish catches by WCDSIMF fishers was taken to the south of the Abrolhos Islands and off Cape Naturaliste in the South-West area (Figure 3.16). While the spatial extent of WA Dhufish catch reported by charter fishers has been relatively widespread, higher catches have been limited to a relatively small number of 5×5 nm reporting blocks (Figure 3.16).

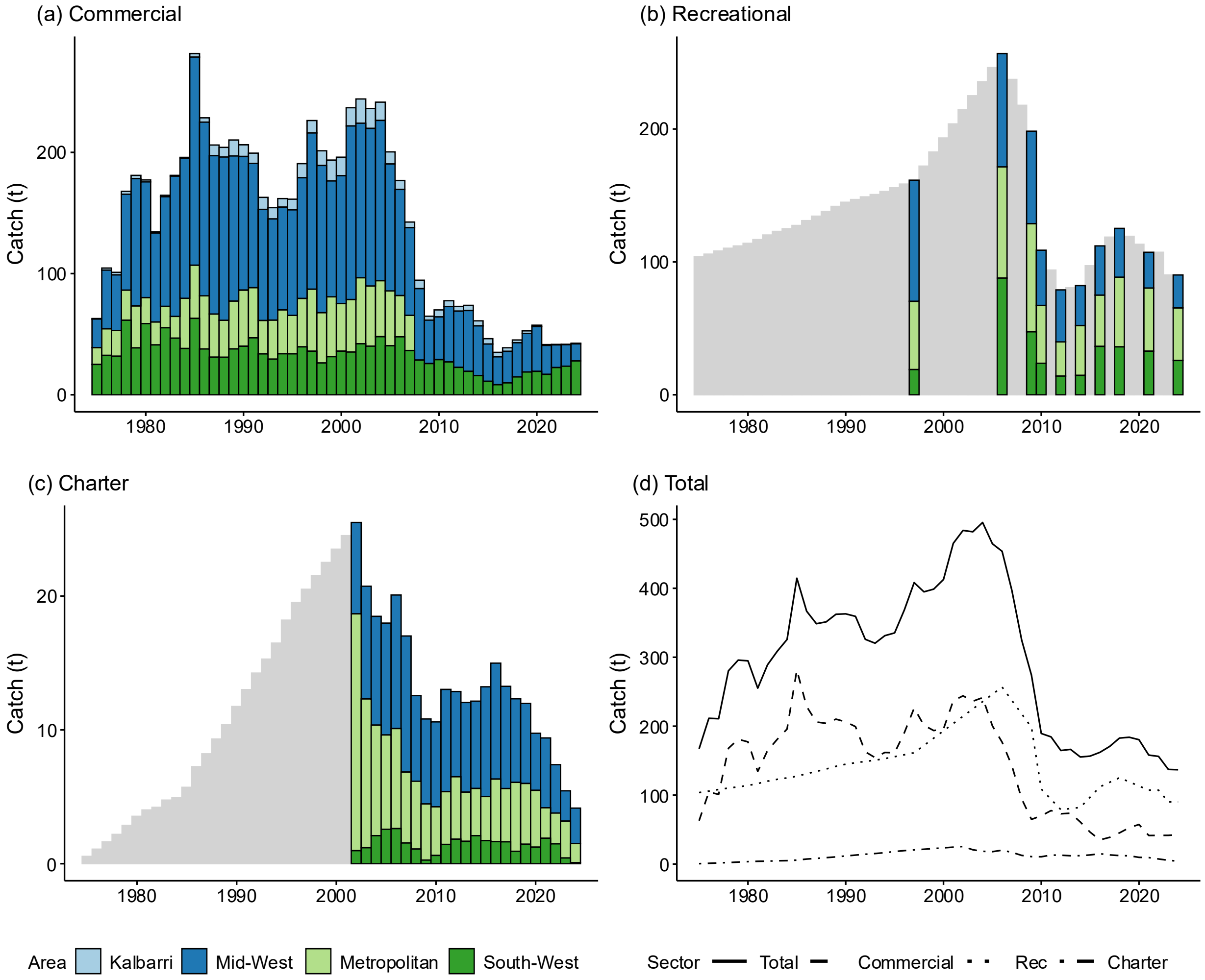


Figure 3.15. Retained catches of WA Dhufish by (a) commercial, (b) recreational and (c) charter fishers in each management area of the WCB since 1975, noting that Kalbarri and Mid-West data are combined for recreational and charter fishers. (d) Time series of total estimated retained catches in the WCB by each sector. The grey bars in the recreational and charter catch plots represent reconstructed catches in years without data, where historical values have been based on changes in population growth and numbers of charter operators.

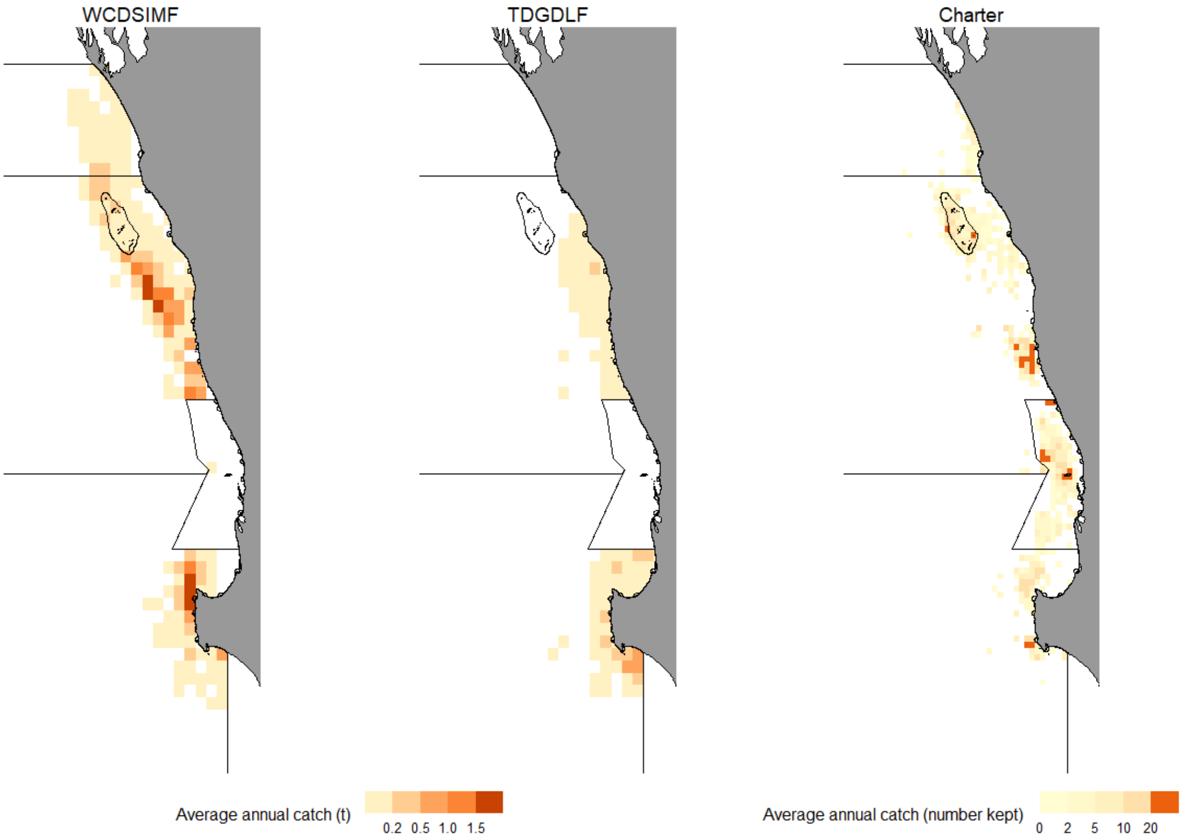


Figure 3.16. Typical distribution of catches of WA dhufish in the WCB based on average annual retained catches (2018–2022) across spatial reporting blocks for the WCDSIMF and TDGDLF (10×10 nm blocks) and charter fishers (5×5 nm blocks). Note the differing scales of plots, with commercial catch reported as weight and charter catch as numbers of fish.

3.3.2 Catch Per Unit Effort

Annual standardised commercial CPUE for WA Dhufish, adjusted to account for assumed changes in fishing efficiency, have been calculated separately for handline and dropline fishing reported in monthly returns and daily logbooks. Dropline CPUE time series derived from monthly logbooks generally show declining trends in the northern and southern WCB from the mid-1980s to the early 1990s, after which the CPUE stabilises at a lower level (Figure 3.17). Time series of CPUE calculated from monthly handline data, which are more uncertain, show a more gradual and consistent decline over the same period (Figure 3.17).

Based on more recent data from daily logbooks in place since 2008, commercial dropline and handline CPUE for WA Dhufish from the northern (primarily Mid-West) management areas show a steady and consistent decline since around 2010, while the handline CPUE time series from the South-West management area shows a slight increasing trend since around 2015 (Figure 3.17).

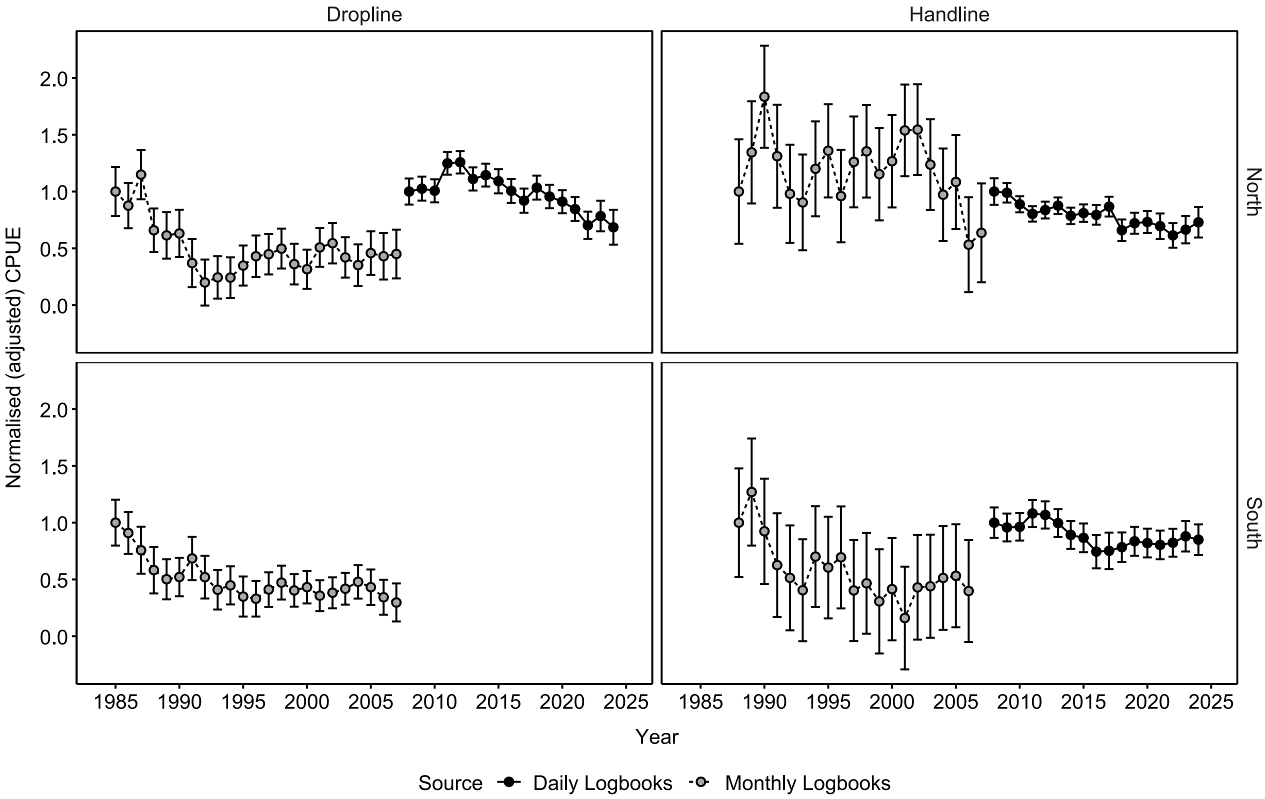
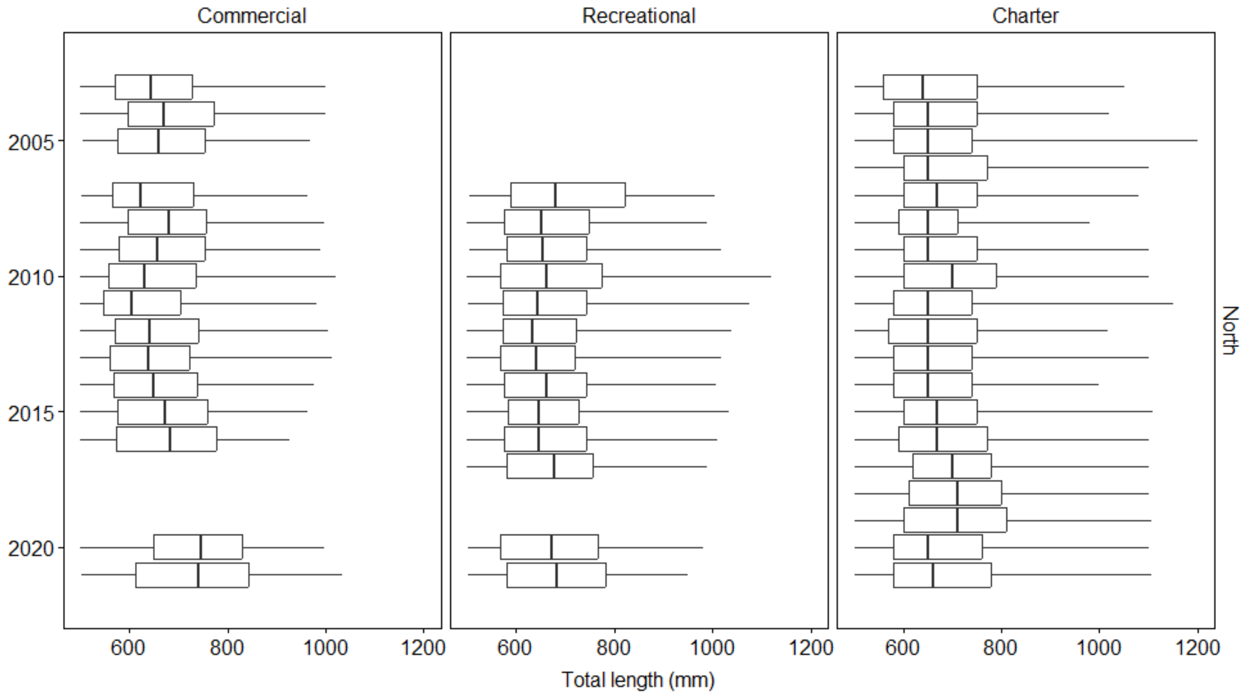


Figure 3.17. Commercial dropline and handline catch per unit effort (CPUE ±95% CI; standardised and adjusted for assumed changes in fishing efficiency) for WA dhufish in the northern and southern WCB, based on data from monthly (grey points, dashed lines) and daily logbooks (black points, solid lines). Note that each time series has been normalised to start at 1.

3.3.3 Length Compositions

Annual length composition data for WA Dhufish in the WCB show that the lengths of retained fish (above the previous MLL of 500 mm) have changed over time (Figure 3.18). While samples from both the northern (primarily Mid-West) and southern (Metropolitan and South-West) areas of the WCB show increasing median lengths of retained fish in recent years, the overall size compositions differ between regions. In the northern WCB, an increased size range of fish have been sampled from commercial and recreational catches in recent years (50% ~ 600–800 m) compared to 2012 when 50% of sampled fish were ~ 550–700 mm (Figure 3.18). In contrast, the size range of fish retained in the southern WCB reduced substantially since from 2015-2018, before starting to increase again (Figure 3.18).

(a) North



(b) South

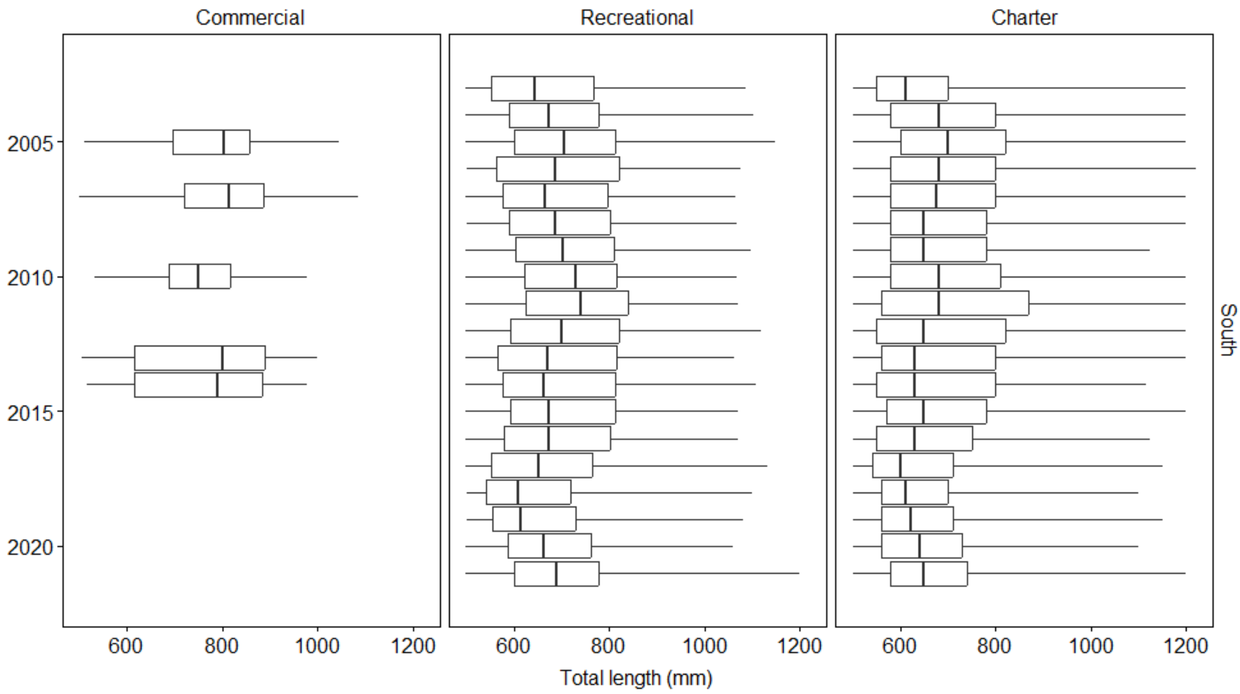


Figure 3.18. Length distributions of WA Dhufish caught by commercial, recreational and charter fishers in the (a) northern (Kalbarri and Mid-West) and (b) southern (Metropolitan and South-West) management areas of the WCB, grouped by biological years (e.g. 2020 is 1 Feb 2020–31 Jan 2021). The boxes represent the 25th, 50th (median) and 75th percentile of observed lengths, with the horizontal lines extending between the minimum and maximum observed values. Only data from years with sample sizes above 100 fish are shown.

3.3.4 Age Compositions

Age data sampled from recreational and commercial catches for WA Dhufish in the WCB show that individuals are first retained by fishers at ~ 5-6 years of age, with greater interannual variability in recruitment to this stock in the south (Metropolitan and South-West) compared to the north (Mid-West) (Figure 3.19). Stronger than average recruitment from cohorts spawned in 1993 and 1999 are visible in data from the Mid-West over several years (Figure 3.19a), with the 1999 cohort also clearly visible in data from the Metropolitan and South-West management areas over time (Figure 3.19b). The age data suggest an increased proportion of older fish (>15 years of age) in the Mid-West in recent sampling years, but with limited evidence of any recent relatively strong recruitment into this region (Figure 3.19a). Age data from recreational catches in the southern WCB show recent catches have been dominated by cohorts spawned around 2010-11, with limited recent recruitment and a reduction in the proportion of sampled fish older than 15 years since the last assessment (Figure 3.19b). The mean age of sampled WA Dhufish has remained relatively stable over time, with a slight increase observed during the last sampling period (Figure 3.20).

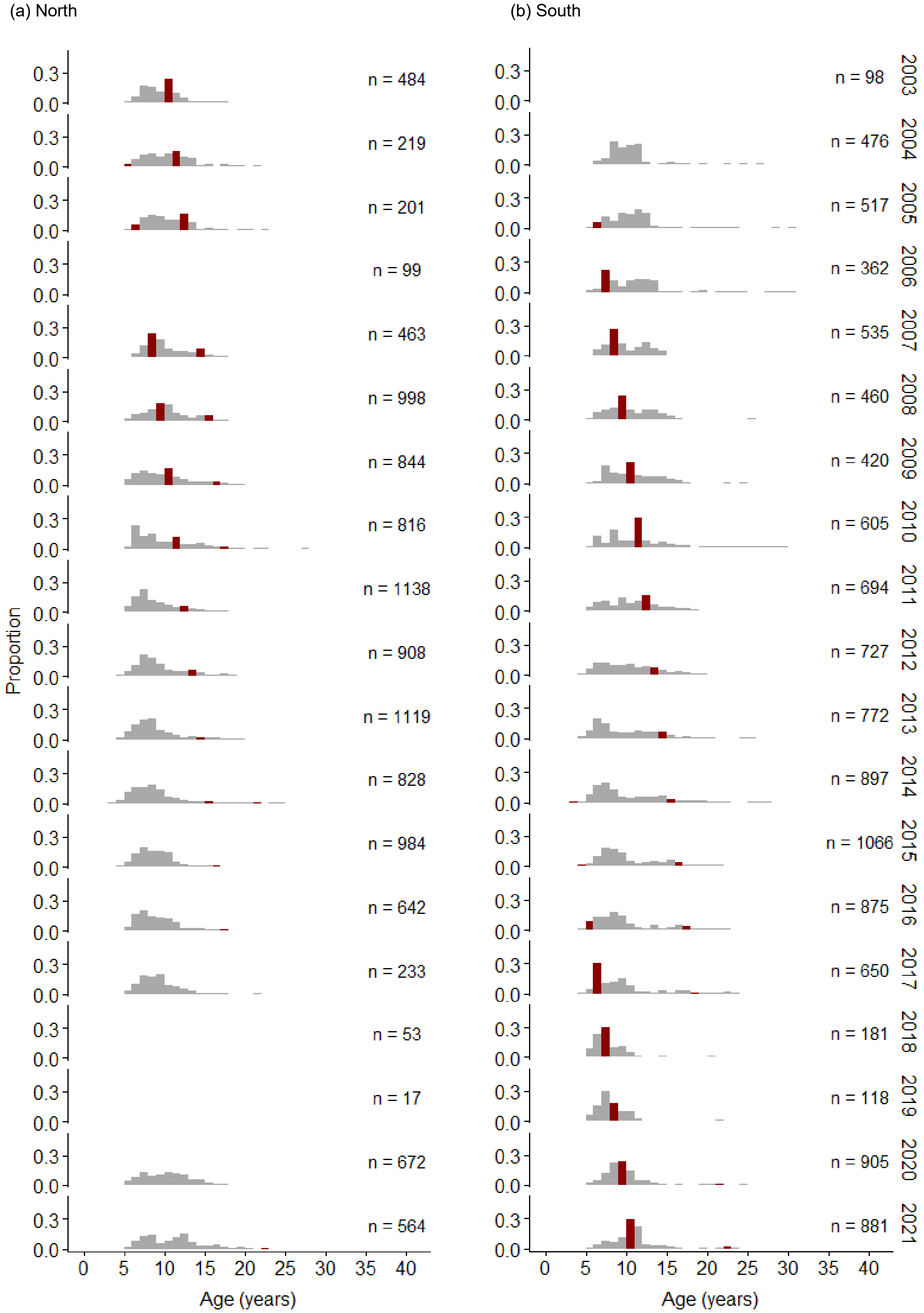


Figure 3.19. Relative age frequencies of WA Dhufish sampled from commercial and/or recreational catches in the (a) northern (primarily Mid-West) and (b) southern management areas of the WCB, grouped by biological years (e.g. 2020 is 1 Feb 2020–31 Jan 2021). Cohorts spawned in the northern WCB in 1993 and 1999, and those spawned in 1999 and 2011 in the southern WCB, are shown in red. Note only data from years with sample sizes above 100 fish are presented.

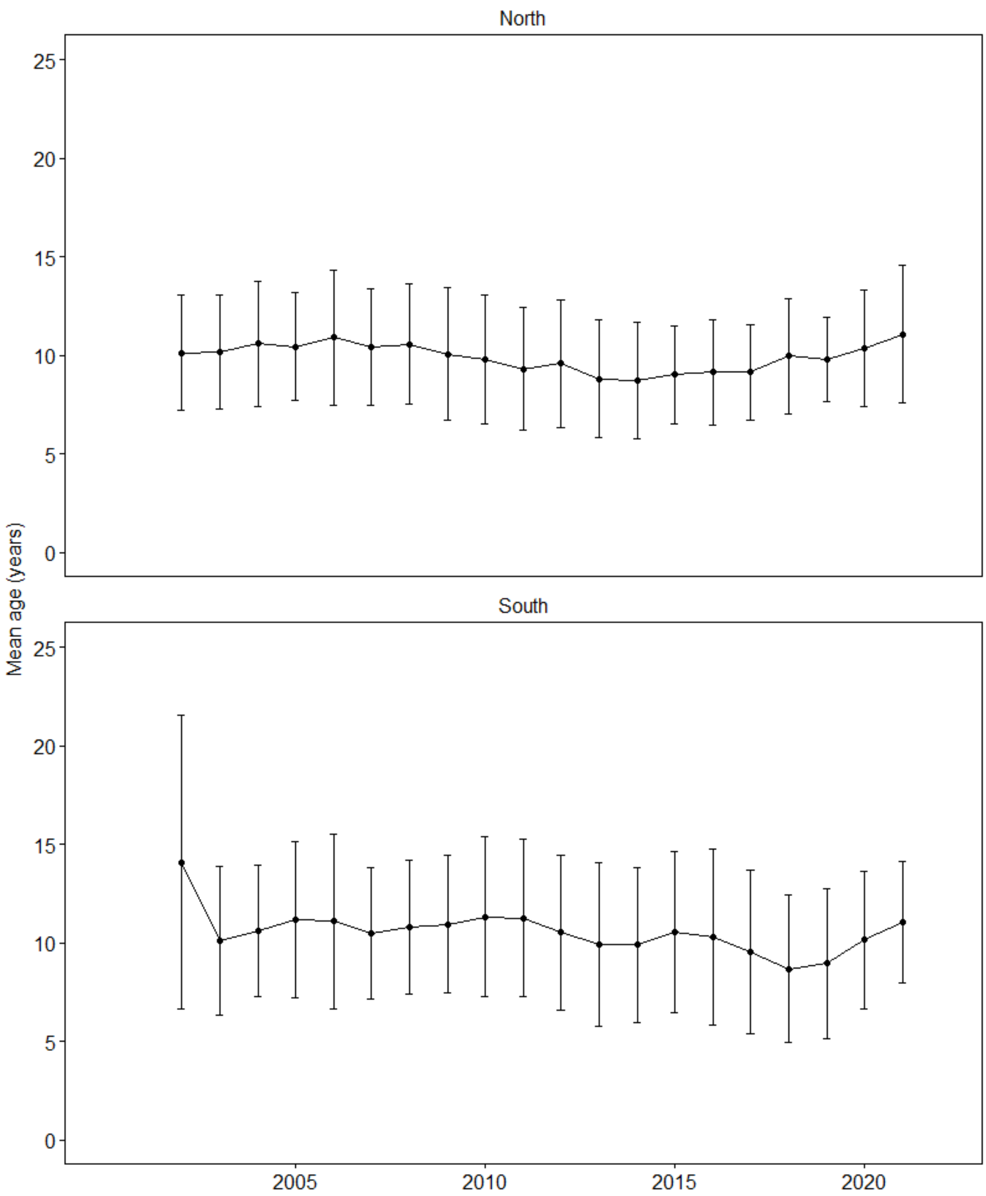


Figure 3.20. Mean age (±SD) of WA Dhufish sampled from commercial and/or recreational catches in the northern (primarily Mid-West) and southern (Metropolitan and South-West) management areas of the WCB, by biological years (e.g. 2020 is 1 Feb 2020–31 Jan 2021).

3.3.5 Environmental Impacts

Recruitment success of demersal species varies markedly between years, influenced in part by environmental factors. Projected increases in water temperature are likely to result in a southward shift in the distribution of WA Dhufish, with reduced catches observed at the northern edge of its distribution in recent years. A strong recruitment of this species in the South-West coincided with the 2010-11 marine heatwave, suggesting warming waters could benefit other parts of the stock. Although projections of a weaker Leeuwin Current and increase El Nino events may affect dispersal of eggs and larvae, the majority settle close to where spawned so the overall impact on the broader stock is uncertain. Based on their biological attributes, WA Dhufish have a medium sensitivity to climate change.

3.3.6 Model Assessment

3.3.6.1 Level 3 Assessment

Estimates of the long-term average *F* of fully selected WA Dhufish in the WCB were derived by fitting an age-based catch curve model that accounts for recruitment variability to age composition data collected between 2018 and 2022 (see Appendix 2 for model fit). Given the recent shift in the modal age (i.e. age-based selectivity) of landed fish, catch curve analyses of WA Dhufish data from the last sampling period assumed a constant age at full selectivity of 9 years of age instead of simultaneously estimating *F* and logistic selectivity parameters (found to influence *F* estimates when sample data were limited to a low number of age classes, results not shown).

The estimated long-term average *F* for fully selected WA Dhufish of 0.21 y^{-1} (at the bioregion level) in 2018-22 was above the limit level of 0.17 y^{-1} (1.5 times the value of *M* for this species of 0.11 y^{-1}; Table 3.3), indicating a slight increase in *F* for the stock compared to the *F* estimated in the 2021 assessment. Estimates of *F* based on samples from the individual management areas indicate a lower recent fishing pressure in the Mid-West compared to the Metropolitan and South-West management areas (Table 3.3), where *F* estimates were markedly higher than the previous sampling period.

Estimates of female B_{rel} for WA Dhufish in the WCB in 2018-22 were derived from a per-recruit model that incorporates a stock-recruitment relationship (steepness set to 0.75) and accounts for the PRM (50%) of released undersized fish (see Appendix 2 for model diagnostics). Model inputs included catch curve estimates of *F* from 2018-22, and available estimates of logistic selectivity parameters from the previous sampling period. Estimates of female B_{rel} for WA Dhufish in the WCB, and estimated separately for the individual management areas, were all below the limit reference level of 0.2 (Table 3.3).

Table 3.3. Catch curve estimates of long-term average *F* (y^{-1}, ±95% CI) and per-recruit estimates of female relative spawning biomass (B_{rel} ± 95% CI) for WA Dhufish based on age composition data collected from commercial and/or recreational catches in the northern (primarily Mid-West) and southern (Metropolitan and South-West) management areas of the WCB in 2018-22. Point estimates were compared to reference levels, where red denotes *F* ≥ limit level of 1.5*M* (0.17 y^{-1}) or B_{rel} ≤ limit level of 0.2.

Area	*F* (±95% CI)	Female B_{rel} (±95% CI)
WCB	0.21 (0.19-0.23)	0.14 (0.09-0.19)
North (Mid-West)	0.22 (0.19-0.25)	0.13 (0.09-0.18)
South	0.20 (0.18-0.22)	0.15 (0.10-0.20)
Metropolitan	0.31 (0.26-0.36)	0.07 (0.03-0.11)
South-West	0.17 (0.15-0.19)	0.19 (0.14-0.24)

3.3.6.2 Level 5 Assessment

The integrated assessment model for WA Dhufish in the WCB (see Appendix 1) was fitted to annual catch and CPUE data up to 2024 (inclusive) and age composition data collected up to 2022 (inclusive), incorporating separate gear selectivity and retention curves to account for the PRM of released undersized fish (assumed to be 50% up to the removals of the MLL in 2023, after which discarding is assumed to have halved; see Ryan et al. 2025).

The estimated female B_{rel} of WA Dhufish (at the bioregion level) in 2024 was 0.15 (95% CI = 0.11–0.19), below the limit reference level of 0.2 (Figure 3.21). This suggests more pessimistic estimates of current stock status compared to the last assessment, which assumed that variability in the recruitment of WA Dhufish between years was the same in the northern and southern parts of the WCB. Estimating recruitment deviations separately for the two regions in this current assessment markedly improves model fits to age composition data (see Appendix 2). Estimates of *F* for both the northern and southern WCB (0.26 and 0.28 y^{-1}, respectively) remain well above the estimated F_{MSY} of 0.1 y^{-1} (Figure 3.21) and the current limit reference level of 1.5*M* (0.165 y^{-1}), demonstrating that overfishing is still occurring.

Model outputs for WA Dhufish in the southern WCB suggest a recent increase in *F* and a slight decline in B_{rel} (Figure 3.21). This is likely due to recent annual catches of ~ 100 t, landed collectively by the recreational and commercial sectors in the Metropolitan and South-West areas, being dominated by only a few cohorts of fish spawned around 2010-11. In the northern WCB, recent annual catches ~ 50 t have led to negligible changes in *F* and B_{rel} in this region (Figure 3.21).

Model projections for WA Dhufish based on an average level of future recruitment indicate that the stock at the bioregion level is unlikely to rebuild above the threshold reference level of B_{MSY} by 2030 even if catches are reduced to the current recovery benchmark. Although highly uncertain, projections under different levels of catch suggest that recovery to the target level may not occur until 2040 unless current catches are substantially reduced.

A preliminary exploration undertaken in this assessment to estimate stock status for WA Dhufish based on an alternative measure for population reproductive output (relative fecundity, E_{rel}, see Evans-Powell et al. 2024) suggest that this measure in 2024 was lower than B_{rel} (0.10 *vs* 0.15), indicating poorer stock status at this time.

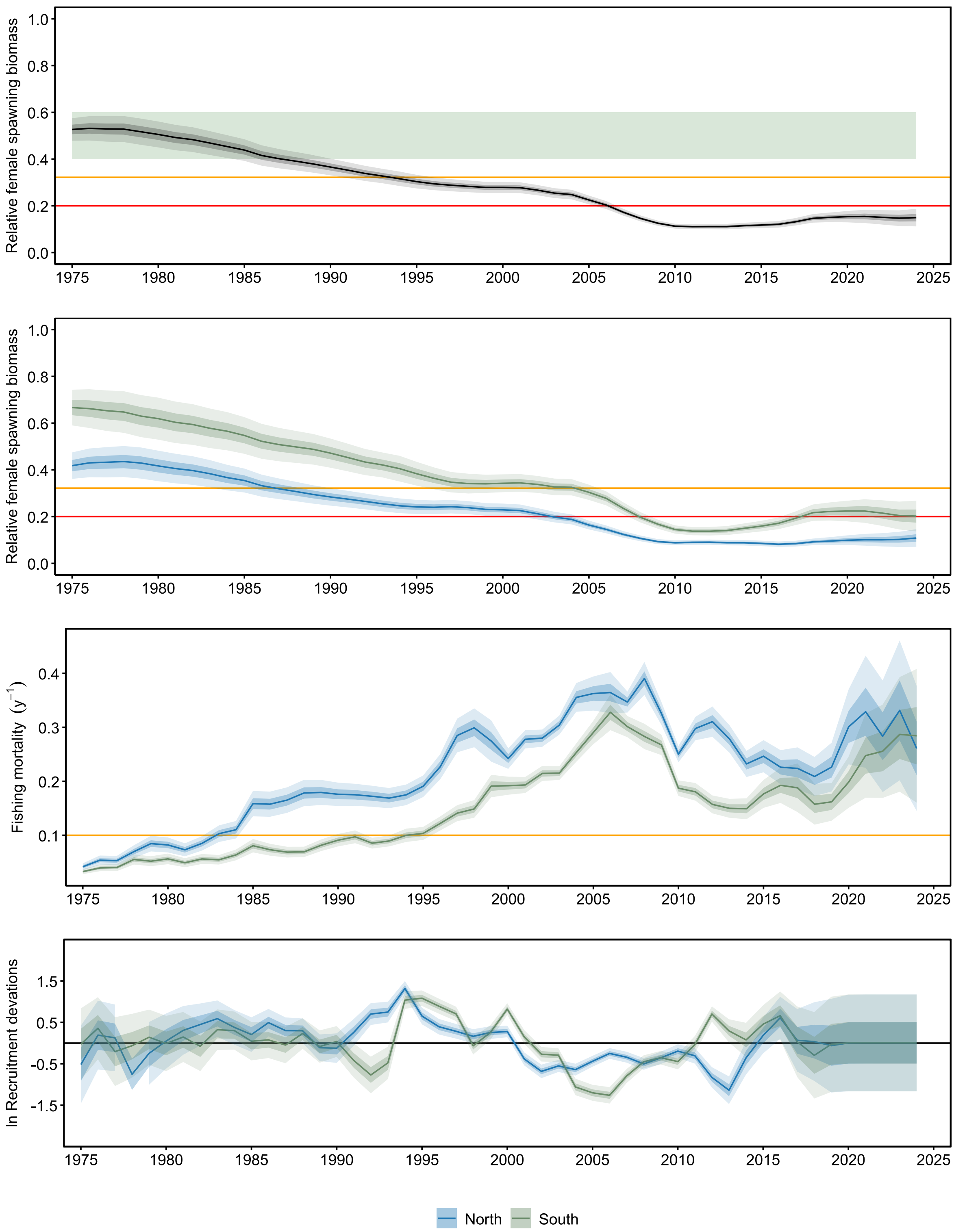


Figure 3.21. (Top) Estimates of annual relative female spawning biomass (B_{rel}) for WA Dhufish in the WCB, and (second from top) estimated separately to for the northern (Kalbarri and Mid-West) and southern (Metropolitan and South-West) management areas, compared to the target (green range), threshold (orange line, B_{MSY}) and limit (red line) reference levels. (Second from bottom) Estimates of annual fishing mortality (F, y^{-1}) for WA Dhufish in the northern and southern WCB, compared to the estimated F_{MSY}. (Bottom) Estimated annual recruitment devations for 1 year old WA Dhufish in the northern and southern WCB. The dark and light shaded areas around each line represent the 60% and 95% CIs, respectively, around estimated model parameters.

3.3.7 Risk-based Weight of Evidence Assessment

Category	Line of Evidence
Catch	Annual retained catches of WA Dhufish in the WCB have reduced markedly since peaking at 500 t in the mid-2000s but increased between 2015 and 2020. The total retained catch in 2024 was 137 t, of which 69% was landed by the recreational sector.
Level 1 Assessment Although catches in the have been relatively stable since the start of the recovery period, an increased proportion of catches taken in the southern WCB is likely associated with a strong pulse of recruitment to this region and could be leading to continued overfishing.	
CPUE	Commercial CPUE data for WA Dhufish from daily logbooks in place since 2008 show a continued decline in dropline CPUE from the northern (primarily Mid-West) management areas, while handline CPUE from the South-West management area shows a slight increasing trend since around 2015.
Level 2 Assessment The declining CPUE trends observed in the northern WCB provides no evidence of stock recovery, while the CPUE trend in the South-West is indicative of some recent increase in abundance within this management area.	
Length Composition	The median lengths of sampled WA Dhufish sampled have increased in recent years. An increased size range of fish has recently been sampled from commercial and recreational catches in the northern WCB, while the size range of fish retained in the southern WCB reduced substantially between 2015 and 2018 before increasing, likely associated with recruitment variability.
Age Composition	Age data show a greater variability in the recruitment of WA Dhufish between years in the southern WCB, with a cohort spawned in 2010-11 dominating recent catches in the South-West area. The data suggest an increased proportion of older fish (>15 years of age) in the Mid-West in recent sampling years, but with limited evidence of any recent relatively strong recruitment into this region.
Equilibrium Biomass Model	The estimated long-term average F for fully selected WA Dhufish in 2018-22 was 0.21 y^{-1} at the stock (bioregion) level (well above the limit reference level of 0.17 y^{-1}). The equilibrium biomass model estimate of female B_{rel} in the WCB of 0.14 (95% CI = 0.09-0.19) was below the limit reference level of 0.2. Area-specific estimates of B_{rel} indicate very low stock levels (0.07) in the Metropolitan management area.

<table>
<tr><td colspan="2">Level 3 Assessment

Consistent with catches being dominated by a limited number of strong cohorts, equilibrium (Level 3) model estimates of F and B_{rel} indicate that the stock is still experiencing overfishing and remains overfished. However, these results should be interpreted with caution due to the equilibrium assumptions of the models used.</td></tr>
<tr><td>Integrated Model</td><td>Integrated model estimates of F for WA Dhufish indicate that exploitation on this stock has remained above acceptable levels and shows a recent increase in F in the southern WCB to well above the limit level reference level of 0.17 y^{-1}. The estimated B_{rel} of 0.15 (95% CI = 0.11-0.19) in the WCB was below the limit level of 0.2 in 2024, with model projections suggesting that the stock is unlikely to rebuild to the threshold level of 0.3 (B_{MSY}) by 2030, even if catches are substantially reduced.</td></tr>
<tr><td colspan="2">Level 5 Assessment

Consistent with outputs from the Level 3 assessment, integrated (Level 5) model estimates of F and B_{rel} show that the stock is still experiencing overfishing and remains overfished.</td></tr>
<tr><td>Environmental Impact</td><td>Warming water temperatures and changes in ocean currents have the potential to affect spawning and recruitment of WA Dhufish. Recent low catches in Kalbarri indicate a potential southward shift in distribution of this species may already be occurring. Based on their biological attributes, WA Dhufish have a medium sensitivity to climate change.</td></tr>
<tr><td colspan="2">Risk Assessment

C1 Minor (Above Target): The likelihood of minor depletion is assessed as Remote (<5%).

C2 Moderate (Above Threshold, below Target): The likelihood of moderate depletion is assessed as Remote (<5%).

C3 High (Above Limit, below Threshold): The likelihood of high depletion is assessed as Remote, with an estimated probability of <5% that B_{rel} of WA Dhufish in the WCB was between the threshold and limit reference levels of 0.3 (B_{MSY}) and 0.2, respectively, in 2024.

C4 Major (Below Limit): The likelihood of major depletion is assessed as Likely, with an estimated probability of >95% that B_{rel} of WA Dhufish in the WCB was below the limit reference level of 0.2 in 2024.

Based on the risk matrix below, the overall risk to WA Dhufish in the WCB is assessed as Severe (C4 × L4).</td></tr>
</table>

Consequence (Stock level)	Likelihood			
	1 Remote (<5%)	2 Unlikely (5-20%)	3 Possible (20-50%)	4 Likely (>50%)
1 Minor (above Target)	X			
2 Moderate (between Target and Threshold)	X			
3 High (between Threshold and Limit)	X			
4 Major (below Limit)				Severe

3.3.8 Assessment Advice

The integrated model assessment of the WA Dhufish in the WCB indicates that Step 1 of the recovery plan, aiming to rebuild biomass above the limit level of 0.2 by 2020, has not been met. Model projections indicate that the stock is unlikely to recover to the threshold level of 0.3 by 2030 (Step 2), even if current catches are substantially reduced.

3.4 Baldchin Groper

3.4.1 Catch

Commercial catches of Baldchin Groper in the WCB have mostly been taken in the Mid-West management area, peaking above 60 t in the late 1980s before reducing to ~ 40 t over the subsequent two decades (Figure 3.22). After the introduction of the WCDSIMF in 2008, commercial catches of this species have decreased to ~ 10–20 t annually. Annual charter catches of Baldchin Groper in the WCB remained relatively stable ~ 10 t from the mid-2000s, before reducing to around 5 t since 2023. Catches retained by private boat-based recreational fishers have fluctuated between 20 t and 40 t since the implementation of management measures to recover the resource in 2010 (Figure 3.22). The total retained catch of Baldchin Groper in the WCB in 2024 was 35 t, of which 80% was collectively retained by the recreational sector (including charter).

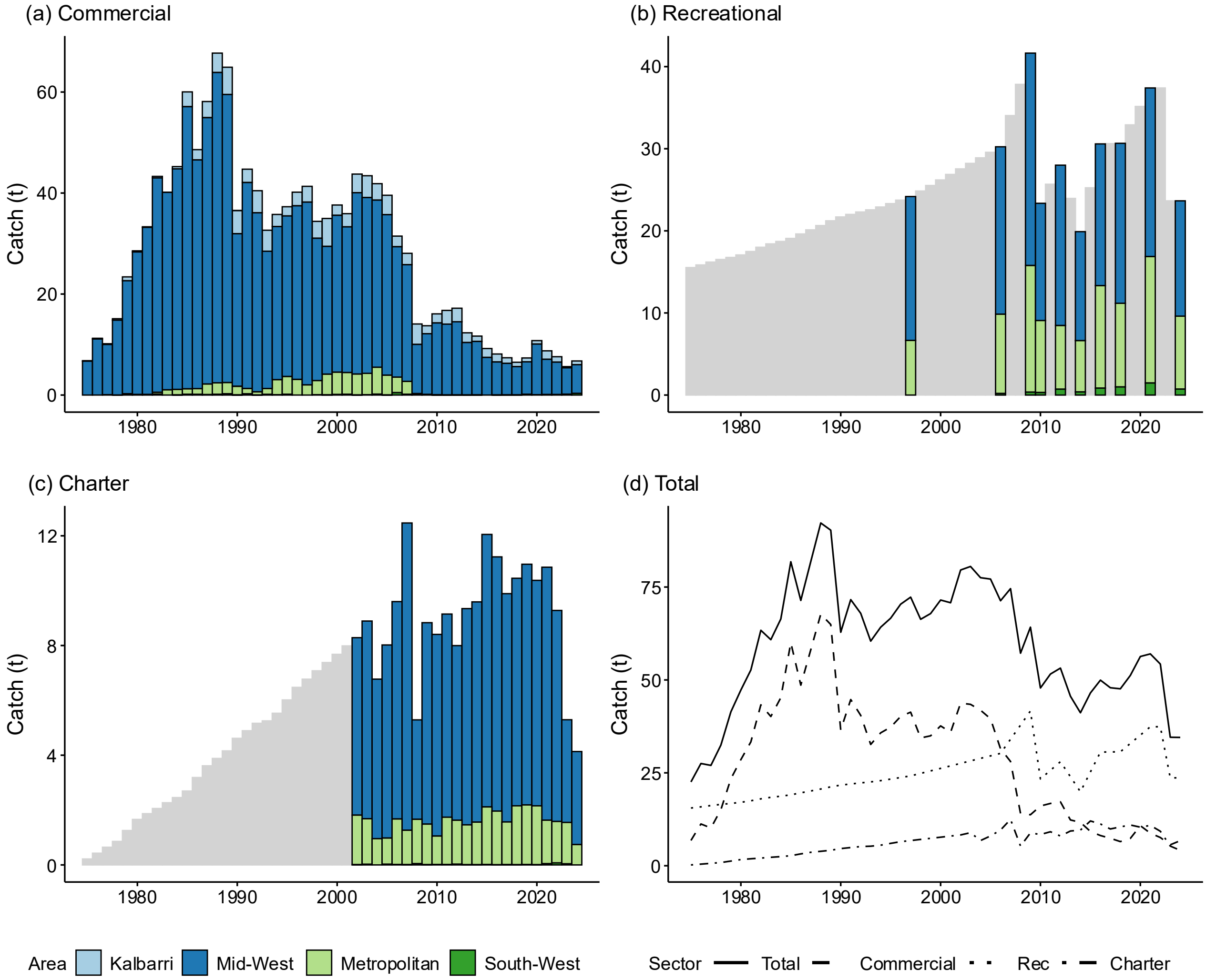


Figure 3.22. Retained catches of Baldchin Groper by (a) commercial, (b) recreational and (c) charter fishers in the WCB since 1975, noting that Kalbarri and Mid-West data are combined for recreational and charter fishers. (d) Time series of total estimated retained catches in the WCB by each sector. The grey bars in the recreational and charter catch plots represent reconstructed catches in years without data, where historical values have been based on changes in population growth and numbers of charter operators.

Data from commercial logbooks show that Baldchin Groper catches by WCDSIMF between 2018 and 2022 were primarily retained around and to the south of the Abrolhos Islands, with TDGDLF catches of this species generally landed closer to shore (Figure 3.23). Catches of Baldchin Groper by charter fishers have also mostly been retained around the Abrolhos Islands, with a smaller number of 5×5 nm reporting blocks with higher catches off Kalbarri, Jurien Bay and in the northern parts of the Metropolitan area (Figure 3.23).

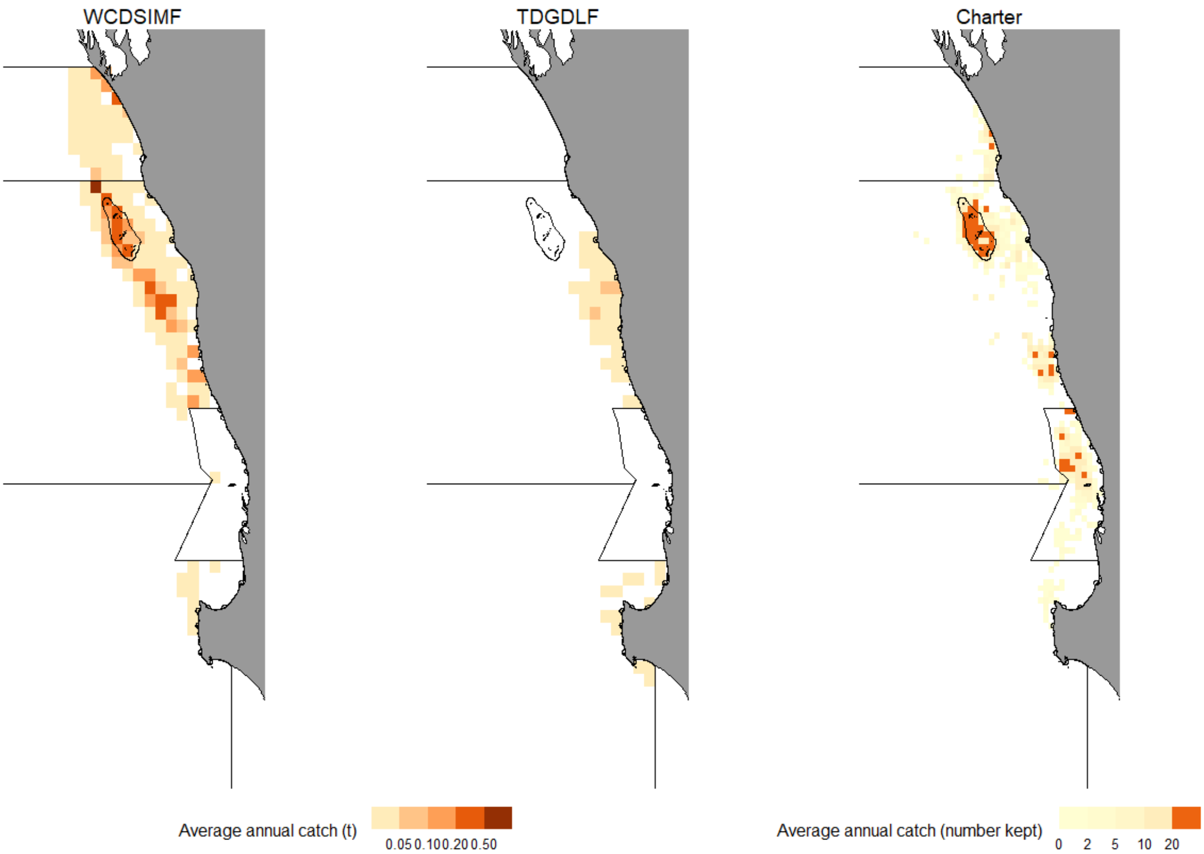


Figure 3.23. Typical distribution of catches of Baldchin Groper in the WCB based on average annual retained catches (2018–2022) across spatial reporting blocks for the WCDSIMF and TDGDLF (10×10 nm blocks) and charter fishers (5×5 nm blocks). Note the differing scales of plots, with commercial catch reported as weight and charter catch as numbers of fish.

3.4.2 Length Compositions

Length compositions of Baldchin Groper (above the previous MLL of 400 mm) in the Mid-West management area of the WCB have been relatively consistent over time, with around half of fish retained by commercial, recreational and charter fishers typically ranging between 450–550 mm (Figure 3.24). The data indicate that the median lengths of fish retained by charter fishers are larger compared to those landed by commercial and recreational fishers (Figure 3.24).

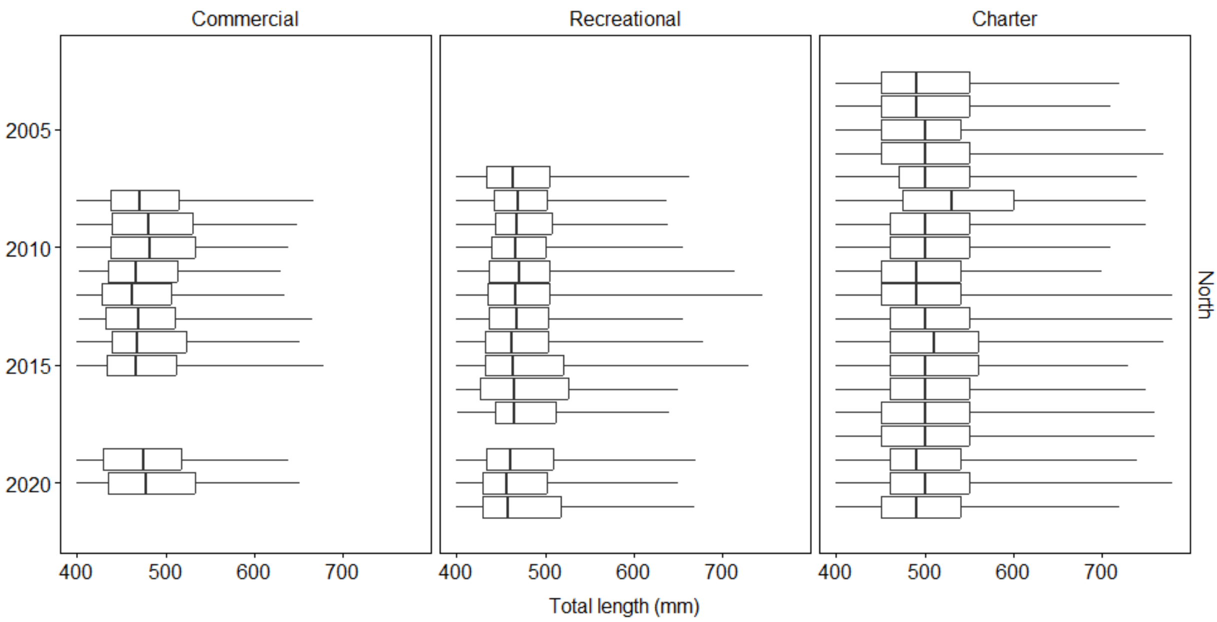


Figure 3.24. Length distributions of Baldchin Groper caught by commercial, recreational and charter fishers in the northern (primarily Mid-West) management areas of the WCB, grouped by biological years (e.g. 2020 is 1 Dec 2020–30 Nov 2021). The boxes represent the 25th, 50th (median) and 75th percentile of observed lengths, with the horizontal lines extending between the minimum and maximum observed values. Only data from years with sample sizes above 100 fish are shown.

3.4.3 Age Compositions

Annual age composition data sampled from commercial and recreational catches of Baldchin Groper in the Mid-West indicate that females are first recruited into the fishery at ~ 6 years of age, with evidence of some variability in recruitment between years (Figure 3.25). The mean age of sampled fish increased from 2007 to 2013 and, more recently, over the last sampling period (2018-22; Figure 3.26), where the latter indicates stronger than average recruitment to this stock from around the time of the 2010-11 marine heatwave. Noting that Baldchin Groper is a protogynous hermaphrodite, there has been no evidence of any marked changes in the sex ratio of recreational catches over time, with ~ 60% of sampled fish being male (data not shown).

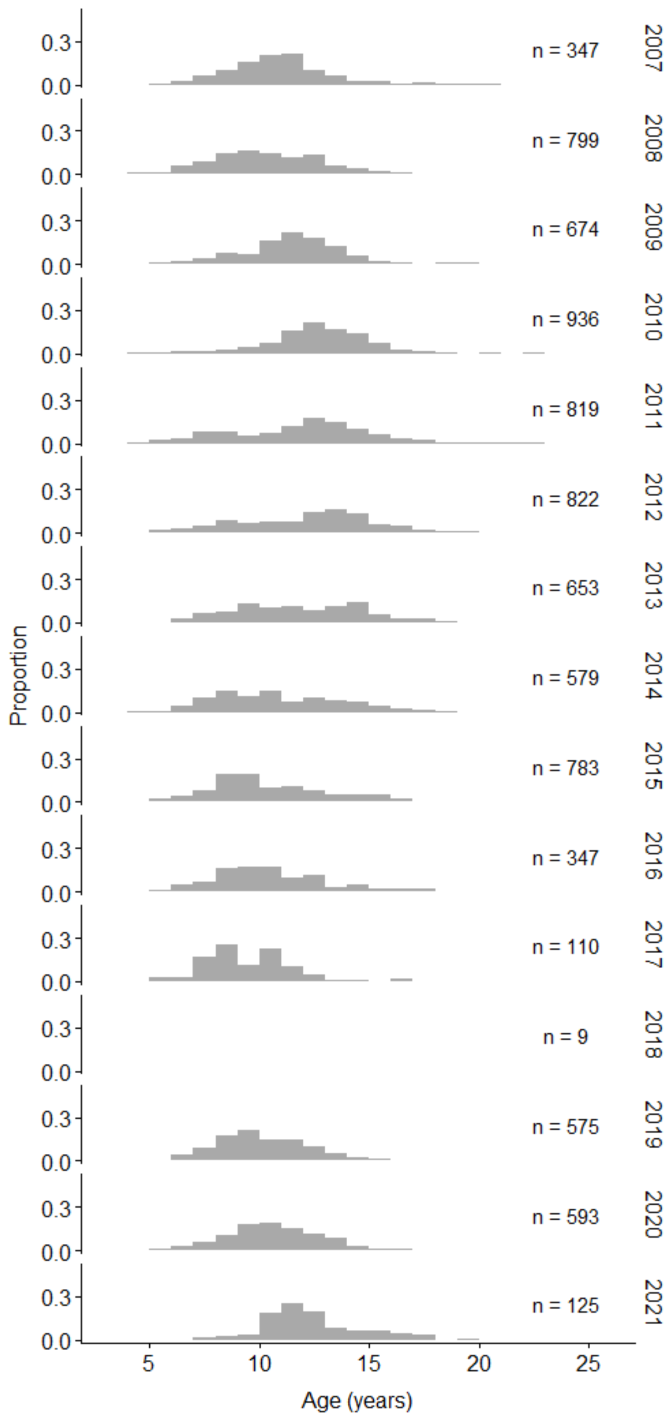


Figure 3.25. Relative age frequencies of Baldchin Groper sampled from commercial and recreational catches in the northern (primarily Mid-West) management areas of the WCB, grouped by biological years (e.g. 2020 is 1 Dec 2020–30 Nov 2021). Note only data from years with sample sizes above 100 fish are presented.

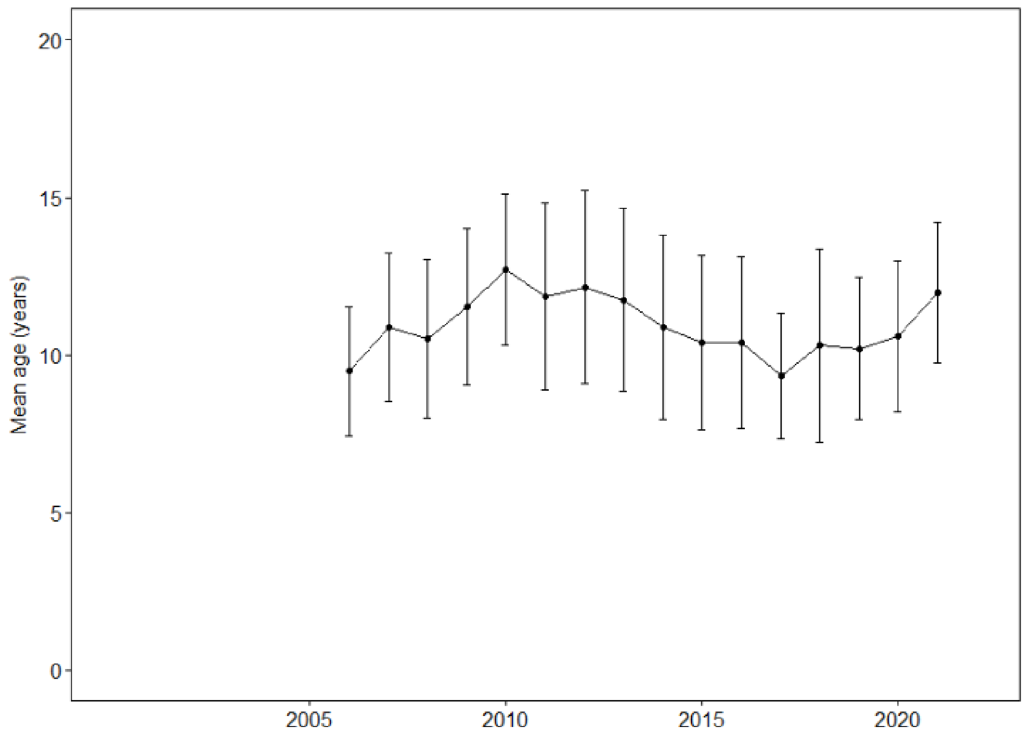


Figure 3.26. Mean age (±SD) of Baldchin Groper sampled from commercial and recreational catches in the Mid-West management area of the WCB, by biological years (e.g. 2020 is 1 Dec 2020–30 Nov 2021).

3.4.4 Environmental Impacts

Recruitment success of demersal species varies markedly between years, influenced in part by environmental factors. Projected increases in water temperature are likely to result in a southward shift in the distribution of Baldchin Groper, with evidence of strong recruitment of this species in the South-West following the 2010-11 marine heatwave. As a tropical species, it has relatively high tolerance for warmer waters, however, there is some uncertainty about the availability of suitable habitats to support larger abundances on south coast. Ocean acidification could also impact on coral reef habitats and diets of this species, due to importance of shelled organisms as a food source. Based on their biological attributes, Baldchin Groper have a medium sensitivity to climate change.

3.4.5 Model Assessment

3.4.5.1 Level 3 Assessment

Based on age composition data for Baldchin Groper collected from commercial and recreational catches in the Mid-West area (for which this species is an indicator) between 2018 and 2022, the estimated long-term F for fully selected fish of 0.24 y^{-1} was between the threshold and limit reference levels of M and $1.5M$ (0.21 and 0.32 y^{-1}), respectively (Table 3.4).

The B_{rel} for Baldchin Groper in the Mid-West area of the WCB was estimated using an equilibrium biomass model that incorporates a stock-recruitment relationship (steepness set to 0.75), female-to-male sex change of this species, and accounts for PRM (90%) of released undersized fish (see Appendix 2 for model diagnostics). The estimated B_{rel}, for both sexes combined, was 0.26 in 2018-22, i.e., between the limit and threshold reference levels of 0.2 and 0.3, respectively (Table 3.4). Corresponding estimates of B_{rel} for female and male Baldchin Groper (results not shown) were above the threshold level and below the limit level, respectively. Although the latter measure is typically considered more precautionary for protogynous species (Fairclough et al. 2014, 2023), the stability in the sex ratio of recreational catches over time (~ 60% male) suggests that the combined sexes B_{rel} may be more appropriate to infer overall stock status of Baldchin Groper (see also Brooks et al. 2008).

Table 3.4. Catch curve estimates of long-term average *F* (y^{-1}, ±95% CI) and per-recruit estimates of relative spawning biomass (B_{rel} ±95% CI, for both sexes combined) for Baldchin Groper based on age composition data collected from commercial and recreational catches in the Mid-West management area of the WCB in 2018-22. Point estimates were compared to reference levels, where orange denotes *F* between the threshold and limit levels of *M* and 1.5*M* (0.21 and 0.32 y^{-1}, respectively) or B_{rel} between the threshold and limit levels of 0.3 and 0.2, respectively.

Area	*F* (±95% CI)	Combined sexes B_{rel} (±95% CI)
Mid-West	0.24 (0.17-0.32)	0.26 (0.19-0.34)

3.4.6 Risk-based Weight of Evidence Assessment

Category	Line of Evidence
Catch	Annual retained catches of Baldchin Groper in the WCB have remained relatively stable since 2010 but with a shift in the proportions of catch landed by the commercial and recreational sectors over time. The total retained catch in 2024 was 35 t, of which 80% was landed by the recreational sector.
Level 1 Assessment Although commercial catches have reduced markedly since the start of the recovery period, continued high catches by the recreational sector could indicate that the stock is still experiencing overfishing.	
Length Composition	Length compositions of Baldchin Groper in the Mid-West management area of the WCB have been relatively consistent over time, mostly ranging between 450-550 mm. Charter fishers report catching much larger individuals of this species than commercial and recreational fishers.
Age Composition	Age data indicate some variability in recruitment between years in the Mid-West, with the mean age of sampled fish increasing from 2007 to 2013, and over the recent 2018-22 sampling period (indicating stronger-than-average recruitment from around the time of the 2010-11 marine heatwave).

Equilibrium Biomass Model	The estimated the long-term average *F* for fully selected Baldchin Groper in the Mid-West area of the WCB was 0.24 y^{-1} in 2018-22 (between the threshold and limit reference levels of 0.21 and 0.32 y^{-1}, respectively) and indicates a reduced exploitation since the start of the recovery period. The equilibrium biomass model estimate of B_{rel} (estimated for both sexes combined for this hermaphroditic species) of 0.26 (95% CI = 0.19-0.34) was between the limit and threshold reference levels of 0.2 and 0.3, respectively.

Level 3 Assessment

Although Level 3 assessment outputs indicate that exploitation has reduced since the start of the recovery period, the estimated long-term *F* remains above the threshold level and B_{rel} of both sexes combined is still below the threshold level. This indicates that overfishing could still be occurring and, if the recent increase in recreational catch continues, it could impact on the rate of stock recovery. These results should be interpreted with caution due to the equilibrium assumptions of the models used.

Environmental Impact	Warming water temperatures are likely to result in a southward shift in the distribution of Baldchin Groper. Given the importance of shelled organisms as a food source, ocean acidification could also have an impact on this species. Based on their biological attributes, they have a medium sensitivity to climate change.

Risk Assessment

C1 Minor (Above Target): The likelihood of minor depletion is assessed as Remote (<5%).

C2 Moderate (Above Threshold, below Target): The likelihood of moderate depletion is assessed as Unlikely (5-20%). Although the estimated female B_{rel} in 2018-22 was above the threshold level of 0.3, estimates for both sexes combined are considered more precautionary for protogynous species.

C3 High (Above Limit, below Threshold): The likelihood of high depletion is assessed as Likely, with the estimated B_{rel} for both sexes combined (including the majority of the 95% CI) in 2018-22 between the threshold (0.3) and limit (0.2) reference levels.

C4 Major (Below Limit): The likelihood of major depletion is assessed as Unlikely, with an estimated probability of <10% that B_{rel} of both sexes combined was below the limit reference level of 0.2 in 2018-22.

Based on the risk matrix below, the overall risk to Baldchin Groper in the Mid-West area of the WCB is assessed as **High** (C3 × L4).

Consequence (Stock level)	Likelihood			
	1 Remote (<5%)	2 Unlikely (5-20%)	3 Possible (20-50%)	4 Likely (>50%)
1 Minor (above Target)	X			
2 Moderate (between Target and Threshold)		X		
3 High (between Threshold and Limit)				High
4 Major (below Limit)		X		

3.4.7 Assessment Advice

The equilibrium-based (Level 3) assessment of Baldchin Groper in the Mid-West indicate that the stock is recovering. As the recovery plan in place for the WCDSR is focused on the highest-risk stocks (Snapper and WA Dhufish), recent management measures taken to reduce fishing pressure on the resource are expected to also benefit Baldchin Groper.

3.5 Redthroat Emperor

3.5.1 Catch

Commercial catches of Redthroat Emperor in the WCB are landed in the Kalbarri and Mid-West management areas (Figure 3.27). While early catch information for this species is uncertain due to inconsistent reporting at the species level, available data suggest that annual catches by the commercial sector increased to a peak above 150 t in the mid-2000s before reducing to ~ 50 t following the introduction of the WCDSIMF in 2008 (Figure 3.27). Annual catches of Redthroat Emperor by boat-based charter and private recreational fishers in the WCB follow similar patterns and have fluctuated below 4 t since the start of the recovery period in 2010 (Figure 3.27). In 2024, the total retained catches of Redthroat Emperor in the WCB was 14 t, of which more than 90% was landed by the commercial sector.

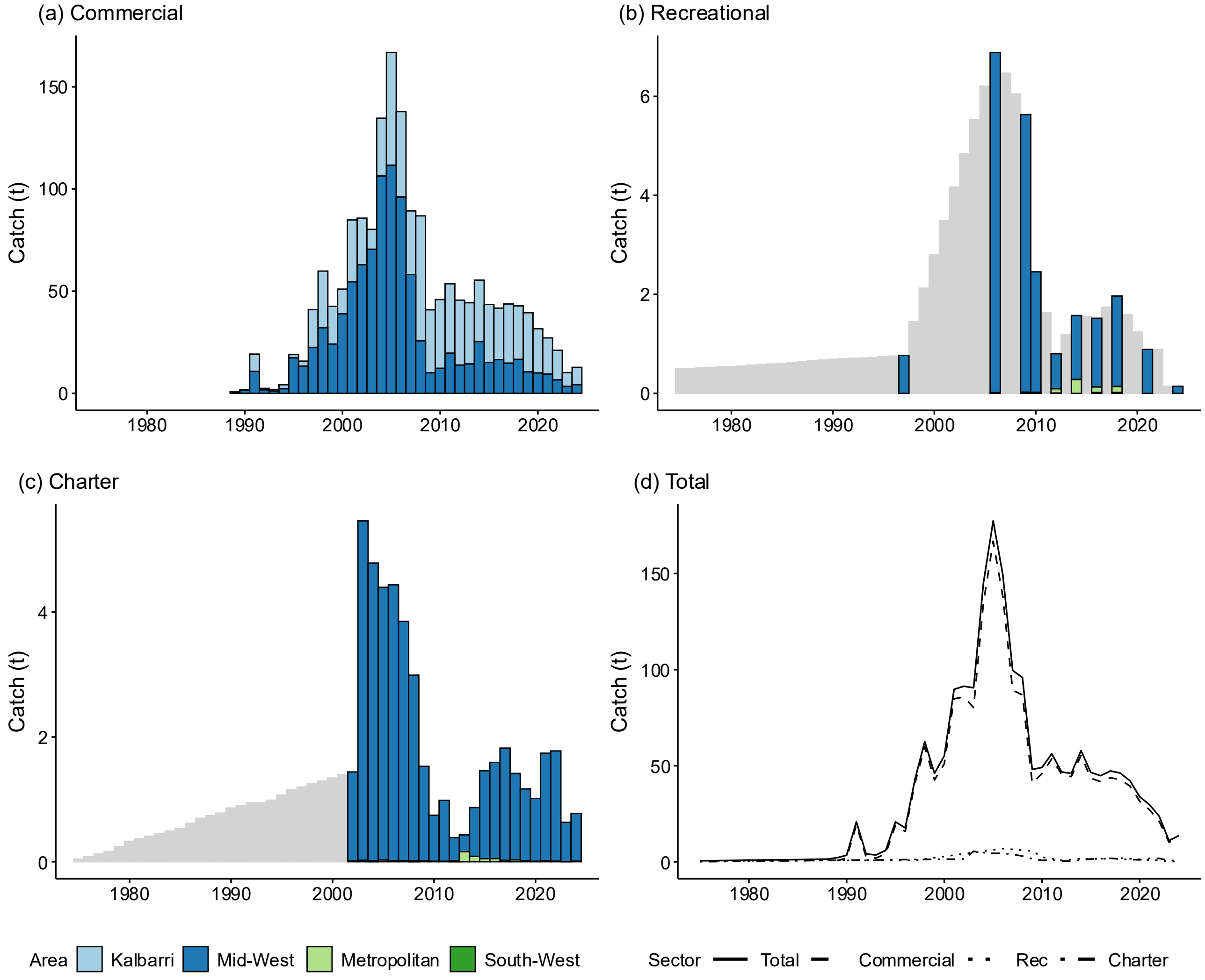


Figure 3.27. Retained catches of Redthroat Emperor by (a) commercial, (b) recreational and (c) charter fishers in the WCB since 1975, noting that Kalbarri and Mid-West data are combined for recreational and charter fishers. (d) Total estimated time series of retained catches across all areas of the WCB by each sector.

Commercial logbook data show that catches of Redthroat Emperor between 2018 and 2022 were almost exclusively retained by the WCDSIMF, with the 10x10 nm reporting blocks with the higher average catches located to the north of the Abrolhos Islands in the Kalbarri management area (Figure 3.28). Recent charter catches of this species primarily been retained around the Abrolhos Islands and in waters relatively close to Kalbarri (Figure 3.28).

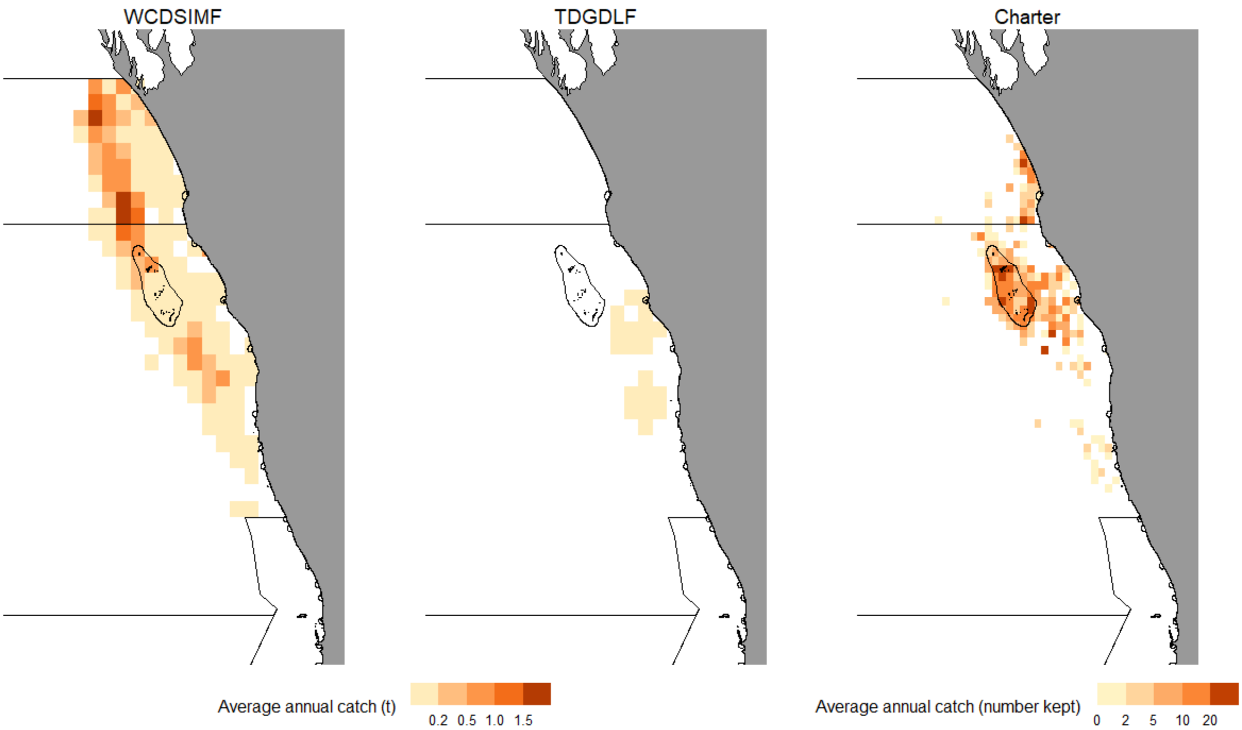


Figure 3.28. Typical distribution of catches of Redthroat Emperor in the WCB based on average annual retained catches (2018–2022) across spatial reporting blocks for the WCDSIMF and TDGDLF (10×10 nm blocks) and charter fishers (5×5 nm blocks) in the northern WCB. Note the differing scales of plots, with commercial catch reported as weight and charter catch as numbers of fish.

3.5.2 Length Compositions

Length compositions of Redthroat Emperor (above the MLL of 280 mm) in the northern (Kalbarri and Mid-West) management areas of the WCB have fluctuated over time, likely as a result of interannual variability in recruitment (Figure 3.29). While the length data sampled periodically from commercial catches are more limited, they broadly show a similar pattern to the length data reported annually in charter logbooks since 2002, indicating increases in the median lengths of retained Redthroat Emperor at an approximate decadal interval (Figure 3.29).

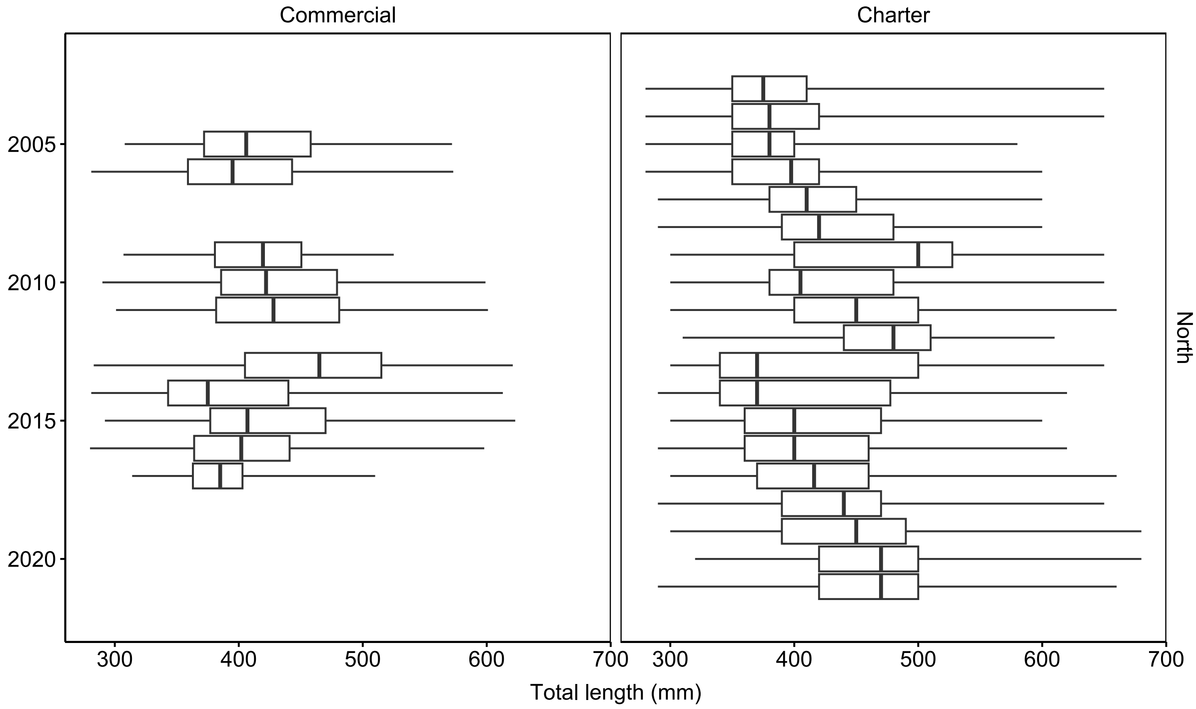


Figure 3.29. Length distributions of Redthroat Emperor caught by commercial and charter fishers in the northern (Kalbarri and Mid-West) management areas of the WCB, grouped by biological years (e.g. 2020 is 1 Jan 2020–31 Dec 2020). The boxes represent the 25th, 50th (median) and 75th percentile of observed lengths, with the horizontal lines extending between the minimum and maximum observed values. Only data from years with sample sizes above 100 fish are shown.

3.5.3 Age Compositions

Annual age composition data sampled periodically from commercial catches of Redthroat Emperor in the northern (Kalbarri and Mid-West) management areas of the WCB indicate that females are first recruited into the fishery at ~ 3-4 years of age (Figure 3.30). Trends in these data suggest that recruitment can vary markedly among years, with the cohort spawned around the time of the 2010-11 marine heatwave clearly visible in data for several consecutive years (Figure 3.30). Noting that Redthroat Emperor is a protogynous hermaphrodite, there is no evidence of any marked changes in the sex ratio of commercial catches over time, with ~ 70-80% of sampled fish in each year being female (data not shown).

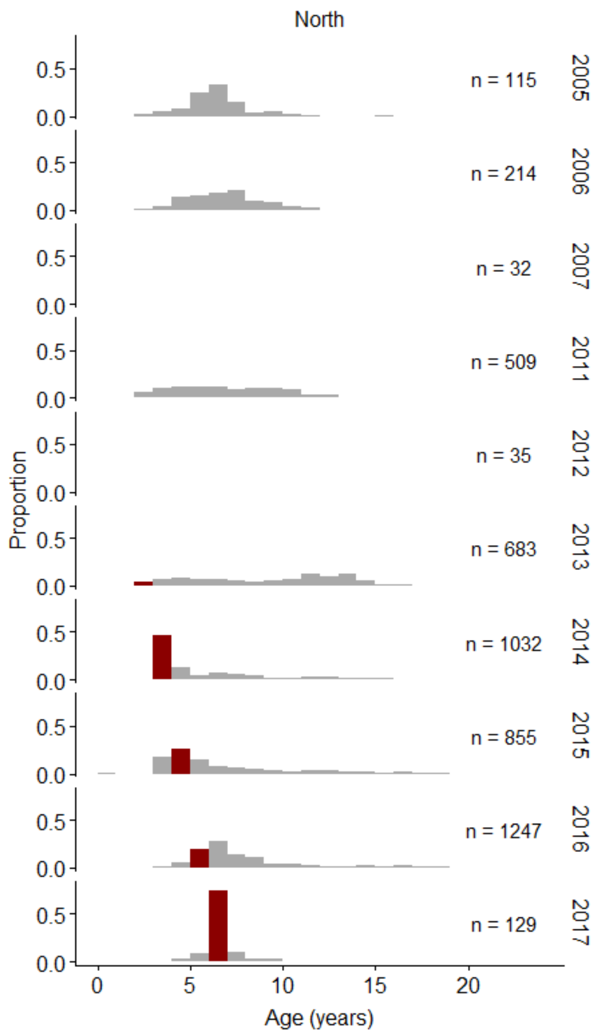


Figure 3.30. Relative age frequencies of Redthroat Emperor sampled from commercial catches in the northern (Kalbarri and Mid-West) management areas of the WCB, grouped by biological years (e.g. 2020 is 1 Jan 2020–31 Dec 2020). The cohort spawned in 2011 is shown in red. Note only data from years with sample sizes above 100 fish are presented.

3.5.4 Environmental Impacts

Recruitment success of demersal species varies markedly between years, influenced in part by environmental factors. Projected increases in water temperature are likely to result in a southward shift in the distribution of Redthroat Emperor and potentially increase catches in the WCB. Although ocean acidification could impact on coral reefs, this species also inhabits other types of reef environments. Based on their biological attributes, Redthroat Emperor have a medium sensitivity to climate change.

3.5.5 Model Assessment

3.5.5.1 Level 3 Assessment

Based on age composition data for Redthroat Emperor collected from commercial catches in the Kalbarri and Mid-West areas of the WCB in the two most recent years of data (2016 and 2017), the estimated long-term *F* for fully selected fish of 0.23 y^{-1} was between the threshold and limit reference levels of *M* and 1.5*M* (0.18 y^{-1} and 0.27 y^{-1}), respectively (Table 3.4, see also Appendix 2).

The B_{rel} for Redthroat Emperor in the northern WCB was estimated using an equilibrium biomass model that incorporates a stock-recruitment relationship (steepness set to 0.75), female-to-male sex change of this species, and accounts for PRM (25%) of released undersized fish (see Appendix 2 for model diagnostics). The estimated B_{rel} for both sexes combined was 0.49 in 2016-17, i.e., between the threshold and target reference levels of 0.3 and 0.5, respectively (Table 3.4). Corresponding estimates of B_{rel} for female and male Redthroat (results not shown) were above the target level and at the threshold level, respectively. Although the latter measure is typically considered more precautionary for protogynous species (Fairclough et al. 2014, 2023), the stability in the sex ratio of recreational catches over time (~ 70-80% female) suggests that the combined sexes B_{rel} may be more appropriate to infer overall stock status of Redthroat Emperor (Brooks et al. 2008).

Table 3.5. Catch curve estimates of long-term average *F* (y^{-1}, ±95% CI) and equilibrium biomass analysis estimates of relative spawning biomass (B_{rel} ±95% CI, for both sexes combined) for Redthroat Emperor based on age composition data collected from commercial catches in the northern (Mid-West and Kalbarri) management areas of the WCB in 2016-17. Point estimates were compared to reference levels, where orange denotes *F* between the threshold and limit levels of *M* and 1.5*M* (0.18 and 0.27 y^{-1}, respectively) and yellow denotes B_{rel} between the target and threshold levels of 0.5 and 0.3, respectively.

Area	*F* (±95% CI)	Combined sexes B_{rel} (±95% CI)
North	0.23 (0.19-0.27)	0.49 (0.38-0.56)

3.5.6 Risk-based Weight of Evidence Assessment

Category	Line of Evidence
Catch	Annual retained catches of Redthroat Emperor in the WCB have reduced markedly since the start of the recovery period in 2010, after peaking ~ 150 t in the mid-2000s. The total retained catch in 2024 was 14 t, of which more than 90% was landed by the commercial sector.
Level 1 Assessment The markedly lower level of catch since the start of the recovery period is indicative of a reduced fishing pressure on this stock.	
Length Composition	Length compositions and the median lengths of Redthroat Emperor caught by commercial and charter fishers in the northern WCB have fluctuated over time in response to variability in annual recruitment.
Age Composition	Age data indicate recruitment of this species varies markedly between years, with a cohort spawned around the time of the 2010-11 marine heatwave clearly visible in data for several consecutive years.

Equilibrium Biomass Model	Based on age composition data from 2016-17, the estimated long-term *F* for Redthroat Emperor in the northern WCB was 0.23, between the threshold and limit reference levels of 0.18 y^{-1} and 0.27 y^{-1}, respectively. The equilibrium biomass model estimate of B_{rel} (estimated for both sexes combined for this hermaphroditic species) was 0.49 (95% CI = 0.38-0.56), just below the target level of 0.5.
Level 3 Assessment Consistent with recent low catches, Level 3 estimates of *F* and B_{rel} indicate a reduced fishing pressure on this stock, allowing it to rebuild above the threshold level. While this suggests that the stock is not overfished, results should be interpreted with caution due to the equilibrium assumptions of the models used.	
Environmental Impact	Warming water temperatures are likely to result in a southward shift in the distribution of Redthroat Emperor and potentially increase catches in the WCB. Based on their biological attributes, they have a medium sensitivity to climate change.
Risk Assessment C1 Minor (Above Target): The likelihood of minor depletion is assessed as Unlikely (5-20%). Although the estimated female B_{rel} in 2016-17 was above the target level of 0.5, estimates for both sexes combined are considered more precautionary for protogynous species. C2 Moderate (Above Threshold, below Target): The likelihood of moderate depletion is assessed as Likely (>50%), with the estimated B_{rel} for both sexes combined (including the majority of the 95% CI) in 2016-17 between the target (0.5) and threshold (0.3) reference levels. C3 High (Above Limit, below Threshold): The likelihood of high depletion is assessed as Remote, with an estimated probability of <5% that B_{rel} of both sexes combined was below the limit reference level of 0.2 in 2016-17. C4 Major (Below Limit): The likelihood of major depletion is assessed as Remote (<5%). Based on the risk matrix below, the overall risk to Redthroat Emperor in the northern WCB is assessed as **Medium** (C2 × L4).	

Consequence (Stock level)	Likelihood			
	1 Remote (<5%)	2 Unlikely (5-20%)	3 Possible (20-50%)	4 Likely (>50%)
1 Minor (above Target)		X		
2 Moderate (between Target and Threshold)				Medium
3 High (between Threshold and Limit)	X			
4 Major (below Limit)	X			

3.5.7 Assessment Advice

Although uncertain, this equilibrium-based (Level 3) assessment of Redthroat Emperor in the northern WCB indicate a Medium (Adequate) level of risk to the stock. As the recovery plan in place for the WCDSR is focused on the highest-risk stocks (Snapper and WA Dhufish), recent management measures taken to reduce fishing pressure on the resource are expected to also benefit Redthroat Emperor.

3.6 Bight Redfish

3.6.1 Catch

Commercial catches of Bight Redfish in the WCB are almost exclusively landed in the South-West management area, with logbook data suggesting that this species first became targeted by fishers in the early 2000s (Figure 3.31). Annual commercial catches increased to a peak above 50 t in the mid-2000s and have broadly fluctuated between 20 t and 40 t since the introduction of the WCDSIMF in 2008 (Figure 3.31). Catches of Bight Redfish retained annually by boat-based charter and private recreational fishers in the Metropolitan and South-West areas of the WCB also peaked around the mid-2000s but have mostly remained below 2 t since the start of the recovery period in 2010. In 2024, the total retained catch of Bight Redfish in the WCB was 36 t, of which 99% was landed by the commercial sector.

Logbook data show that WCDSIMF catches of Bight Redfish between 2018 and 2022 were relatively widespread in waters off the southern Capes region. In contrast, charter catches of this species have been primarily taken in the Metropolitan area and, to a lesser extent, in waters off Cape Naturaliste (Figure 3.32).

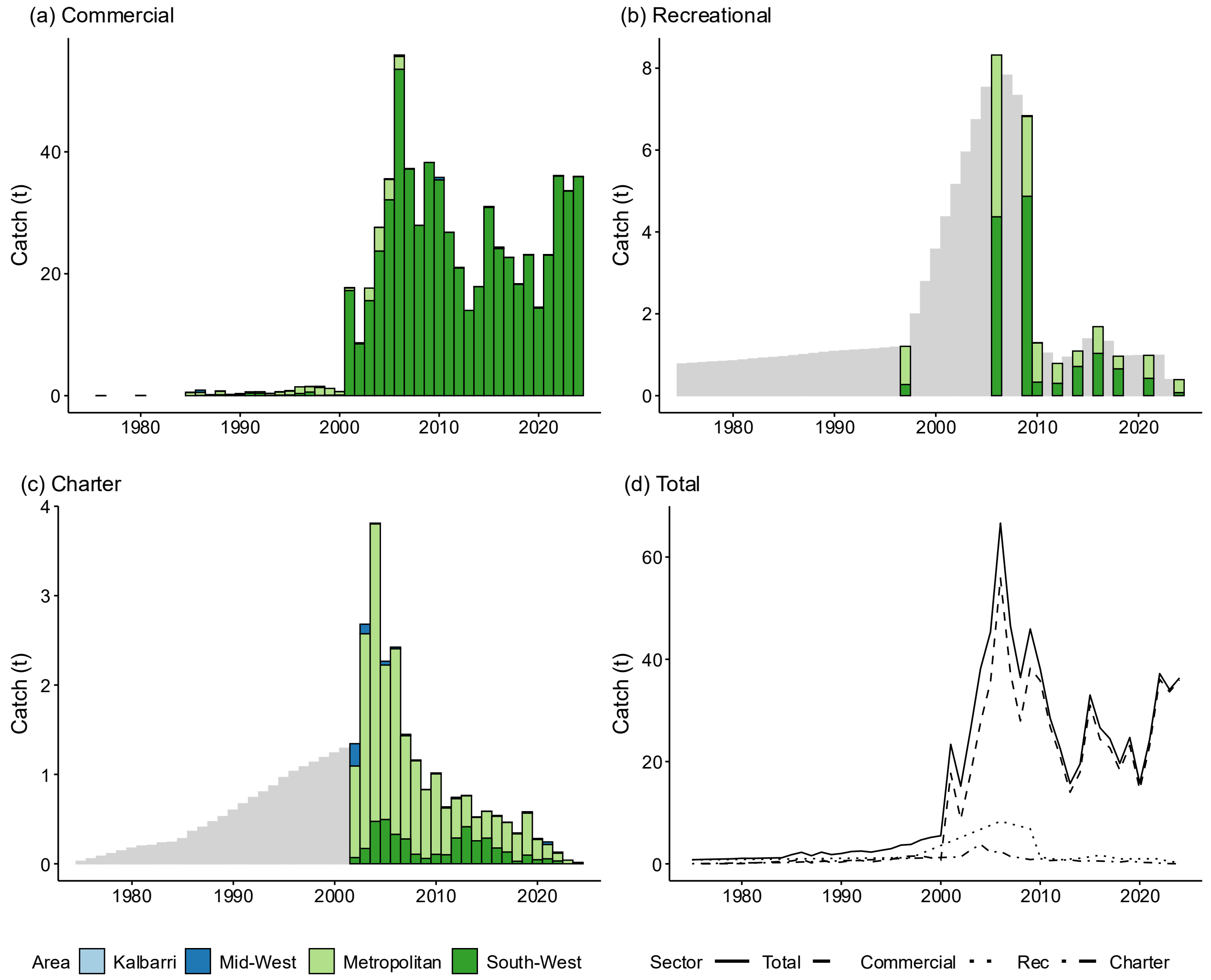


Figure 3.31. Retained catches of Bight Redfish by (a) commercial, (b) recreational and (c) charter fishers in the WCB since 1975. (d) Total estimated time series of retained catches across all areas of the WCB by each sector.

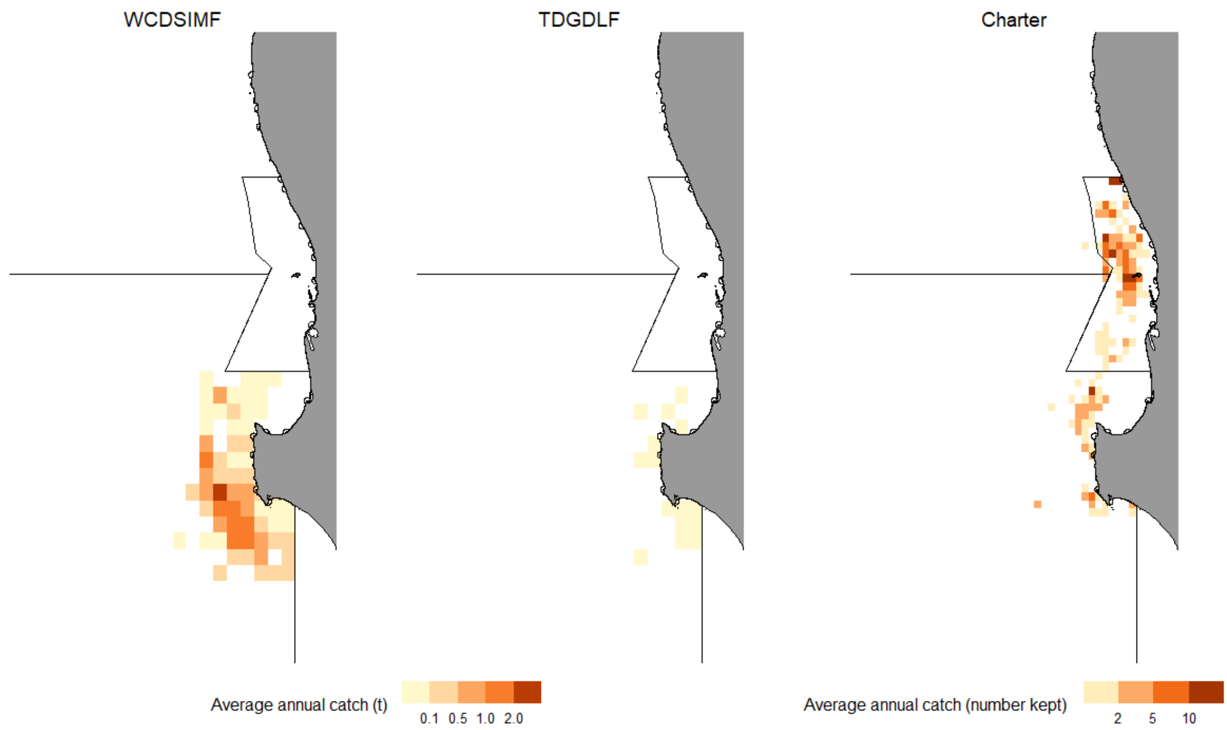


Figure 3.32. Typical distribution of catches of Bight Redfish in the WCB based on average annual retained catches (2018–2022) across spatial reporting blocks for the WCDSIMF and TDGDLF (10×10 nm blocks) and charter fishers (5×5 nm blocks) in the southern WCB. Note the differing scales of plots, with commercial catch reported as weight and charter catch as numbers of fish.

3.6.2 Length Compositions

Length compositions of Bight Redfish (above the MLL of 300 mm) caught by commercial and charter fishers in the southern management areas of the WCB have been relatively consistent over time (Figure 3.33). In each year of available data, larger fish were generally sampled from commercial catches landed in the South-West area of the WCB compared to those reported in charter logbooks, which were primarily caught in the Metropolitan area (Figure 3.33).

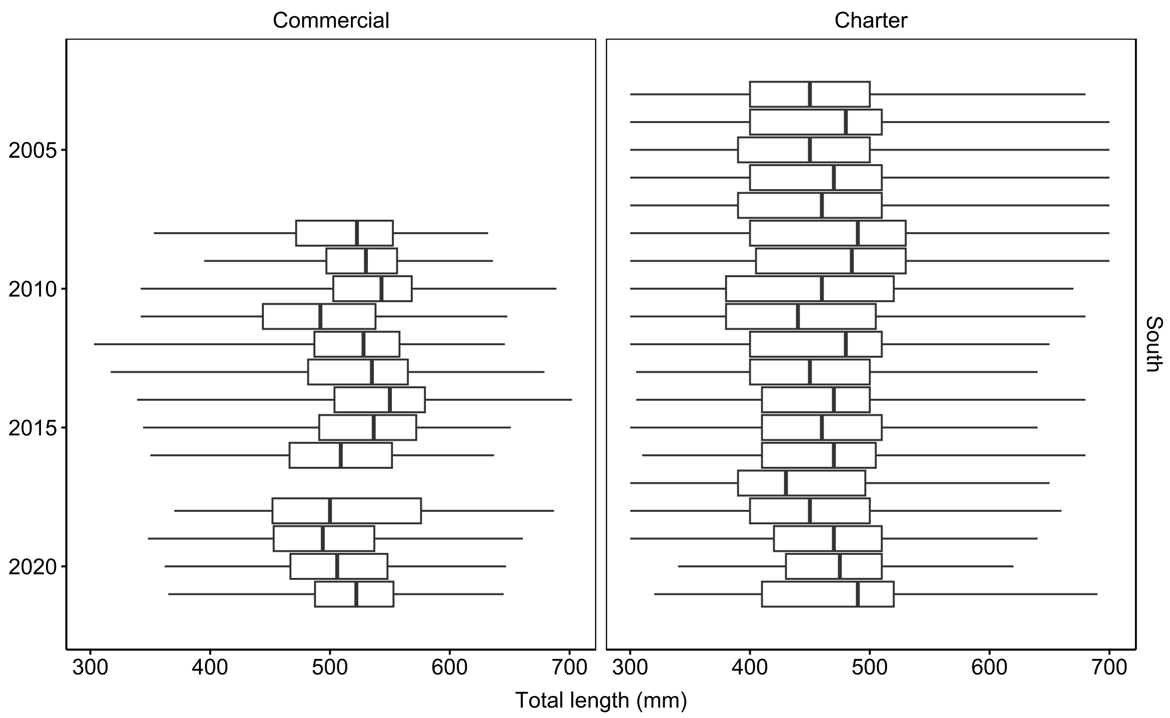


Figure 3.33. Length distributions of Bight Redfish caught by commercial and charter fishers in the southern (South-West and Metropolitan) management areas of the WCB, grouped by biological years (e.g. 2020 is 1 Apr 2020–31 Mar 2021). The boxes represent the 25th, 50th (median) and 75th percentile of observed lengths, with the horizontal lines extending between the minimum and maximum observed values. Only data from years with sample sizes above 100 fish are shown.

3.6.3 Age Compositions

Age compositions sampled from commercial catches of Bight Redfish in the South-West management area of the WCB suggest individuals are only recruited into the fishery at ~ 10-15 years of age (Figure 3.34). The data for this exceptionally long-lived species (maximum recorded age of 84 years) show a healthy spread of ages in the population, with relatively large numbers of old (> 30-year-old) fish represented in catches over time (Figure 3.34).

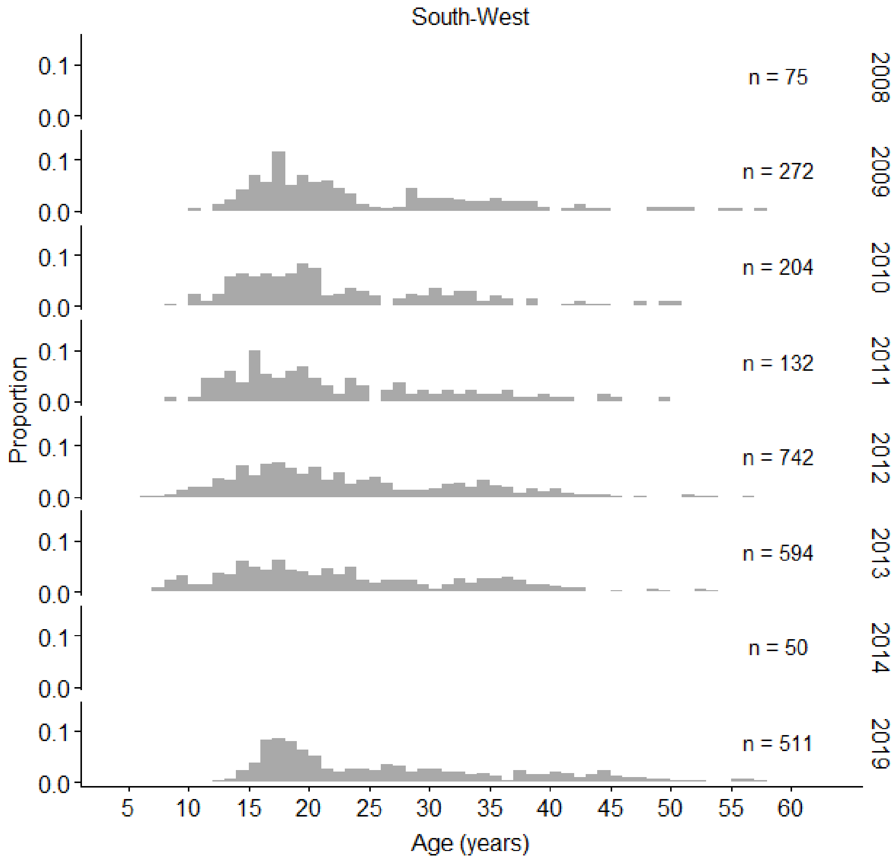


Figure 3.34. Relative age frequencies of Bight Redfish sampled from commercial catches in the southern (Metropolitan and South-West) management areas of the WCB, grouped by biological years (e.g. 2020 is 1 Apr 2020–31 Mar 2021). Note only data from years with sample sizes above 100 fish are presented.

3.6.4 Environmental Impacts

Projected increases in water temperature and more frequent marine heatwaves may lead to a southward shift in the distribution of this temperate species, with key spawning areas associated with upwelling areas in the South-West already at the northern extent of its range. Although projections of a weaker Leeuwin Current could affect dispersal of eggs and larvae, the overall impacts on the broader stock are uncertain. Based on their biological attributes, Bight Redfish have a medium sensitivity to climate change.

3.6.5 Model Assessment

3.6.5.1 Level 3 Assessment

Based on the age composition data for Bight Redfish sampled from commercial catches in the South-West area of the WCB in 2019, the long-term *F* for fully selected fish of 0.03 y^{-1}, estimated using the Chapman & Robson (1960) catch curve approach, was at the target reference level corresponding to 2/3*M* (Table 3.6, see also Appendix 2). This *F* estimate was slightly lower that estimated by the catch curve method accounting for variable recruitment (0.06 y^{-1}, based on earlier data from 2012-14, as this method requires multiple consecutive years of samples). Chapman & Robson (1960) estimates of *F* based on those same data from 2012 and 2013 suggest a slight downward trend in *F* over recent years (0.05, 0.04 and 0.03 y^{-1}, respectively).

The B_{rel} was estimated for female Bight Redfish in the South-West WCB using an equilibrium biomass model that incorporates a stock-recruitment relationship (steepness set to 0.75) and accounts for PRM (25%) of released undersized fish (see Appendix 2 for model diagnostics). Based on the Chapman & Robson (1960) estimate *F* from 2019 and age-based logistic selectivity (retention) parameters estimates from 2012-14 data, the estimated female B_{rel} was just above the target level of 0.5 (Table 3.6), indicative of acceptable stock levels.

Table 3.6. Catch curve estimates of long-term average *F* (y^{-1}, ±95% CI) and equilibrium biomass analysis estimates of female relative spawning biomass (B_{rel} ±95% CI) for Bight Redfish based on age composition data collected from commercial catches in the South-West management area of the WCB in 2019. Point estimates were compared to reference levels, where yellow denotes *F* between the target and threshold levels of 2/3*M* and *M* (0.03 and 0.05 y^{-1}, respectively) and green denotes B_{rel} ≥ target level of 0.5.

Area	*F* (±95% CI)	Female B_{rel} (±95% CI)
South-West	0.03 (0.02-0.04)	0.58 (0.50-0.63)

3.6.6 Risk-based Weight of Evidence Assessment

Category	Line of Evidence
Catch	Annual retained catches of Bight Redfish in the WCB peaked ~ 60 t in the mid-2000s but have fluctuated at a lower level since the start of the recovery period in 2010. The total retained catch in 2024 was 36 t, of which 99% was landed by the commercial sector.
Level 1 Assessment Large fluctuations in commercial catches since the start of the recovery period, possibly driven by variations in targeted fishing effort and/or variability in recruitment, could indicate that the stock is experiencing overfishing.	
Length Composition	Annual length compositions of Bight Redfish caught by commercial and charter fishers in the southern WCB have remained relatively stable over time, with commercial fishers landing much larger individuals of this species than those reported by charter fishers.
Age Composition	Bight Redfish age data from the South-West area of the WCB indicate that this species is only selected by this fishery at ~ 10-15 years of age. A 2019 sample indicates a healthy spread of ages and good representation of older fish (> 30 years) in the population.

<table>
<tr><td>Equilibrium Biomass Model</td><td>Given the uncertainties around the connectivity of Bight Redfish in the WCB with those on the southern coast of WA, the current assessment of this species is focused on outputs from equilibrium-based model assessments undertaken separately for the two bioregions. Based on age composition data collected in 2019, the Chapman and Robson estimate of long-term F for fully selected fish in the South-West area of the WCB was at the target reference level of 0.03 y^{-1}. The corresponding equilibrium biomass model estimate of female B_{rel} was 0.58 (95% CI = 0.50-0.63), above the target reference level of 0.5.</td></tr>
<tr><td colspan="2">Level 3 Assessment
Equilibrium-based (Level 3) model estimates of F and B_{rel} indicate that overfishing is not occurring, and the stock is not overfished. The results should be interpreted with some caution due to the equilibrium assumptions of the models used and uncertainty around connectivity of this population with fish caught on the south coast of WA.</td></tr>
<tr><td>Environmental Impact</td><td>Warming water temperatures may lead to a southward shift in the distribution of Bight Redfish, with key spawning areas associated with upwelling areas in the South-West WCB already at the northern extent of its range. Based on their biological attributes, they have a medium sensitivity to climate change.</td></tr>
<tr><td colspan="2">Risk Assessment
C1 Minor (Above Target): As the estimated female B_{rel} and 95% CIs were at or above the target level of 0.5, the likelihood of minor depletion is assessed as Likely (>50%).
C2 Moderate (Above Threshold, below Target): As the 95% CIs of the estimated female B_{rel} was at or above the target level, the likelihood of moderate depletion is assessed as Unlikely (5-20%).
C3 High (Above Limit, below Threshold): The likelihood of high depletion is assessed as Remote (<5%).
C4 Major (Below Limit): The likelihood of major depletion is assessed as Remote (<5%).
Based on the risk matrix below, the overall risk to Bight Redfish in the South-West management area of the WCB is assessed as Low (C4 × L1).</td></tr>
</table>

Consequence (Stock level)	Likelihood			
	1 Remote (<5%)	2 Unlikely (5-20%)	3 Possible (20-50%)	4 Likely (>50%)
1 Minor (above Target)				X
2 Moderate (between Target and Threshold)		X		
3 High (between Threshold and Limit)	X			
4 Major (below Limit)	Low			

3.6.7 Assessment Advice

Although uncertain, this (equilibrium-based Level 3) assessment of Bight Redfish in the South-West area indicate a Low (Adequate) risk to the stock. As the recovery plan in place for the WCDSR is focused on the highest-risk stocks (Snapper and WA Dhufish), recent management measures taken to reduce fishing pressure on the resource are expected to also benefit Bight Redfish.

3.7 Breaksea Cod

3.7.1 Catch

Commercial catches of Breaksea Cod in the WCB were first reported in the early 2000s and peaked at 8 t in 2004 before reducing to ~ 2-4 t annually since the introduction of the WCDSIMF in 2008 (Figure 3.35). While early commercial catches were spread across all management areas of the WCB, recent catches have been primarily landed in the Mid-West (Figure 3.35). Catches of Breaksea Cod by the recreational sector in the WCB, which have primarily been landed in the Metropolitan area, peaked just below 30 t in the early to mid-2000s (Figure 3.35). Since the start of the recovery period in 2010, annual Breaksea Cod catches by charter fishers have gradually reduced to ~ 1 t, while those landed by private recreational fishers remained stable at ~ 10 t before reducing to 6 t in 2023-24 (Figure 3.35). In 2024, the total retained catch of Breaksea Cod in the WCB was 8 t, of which more than 80% was collectively landed by the recreational sector.

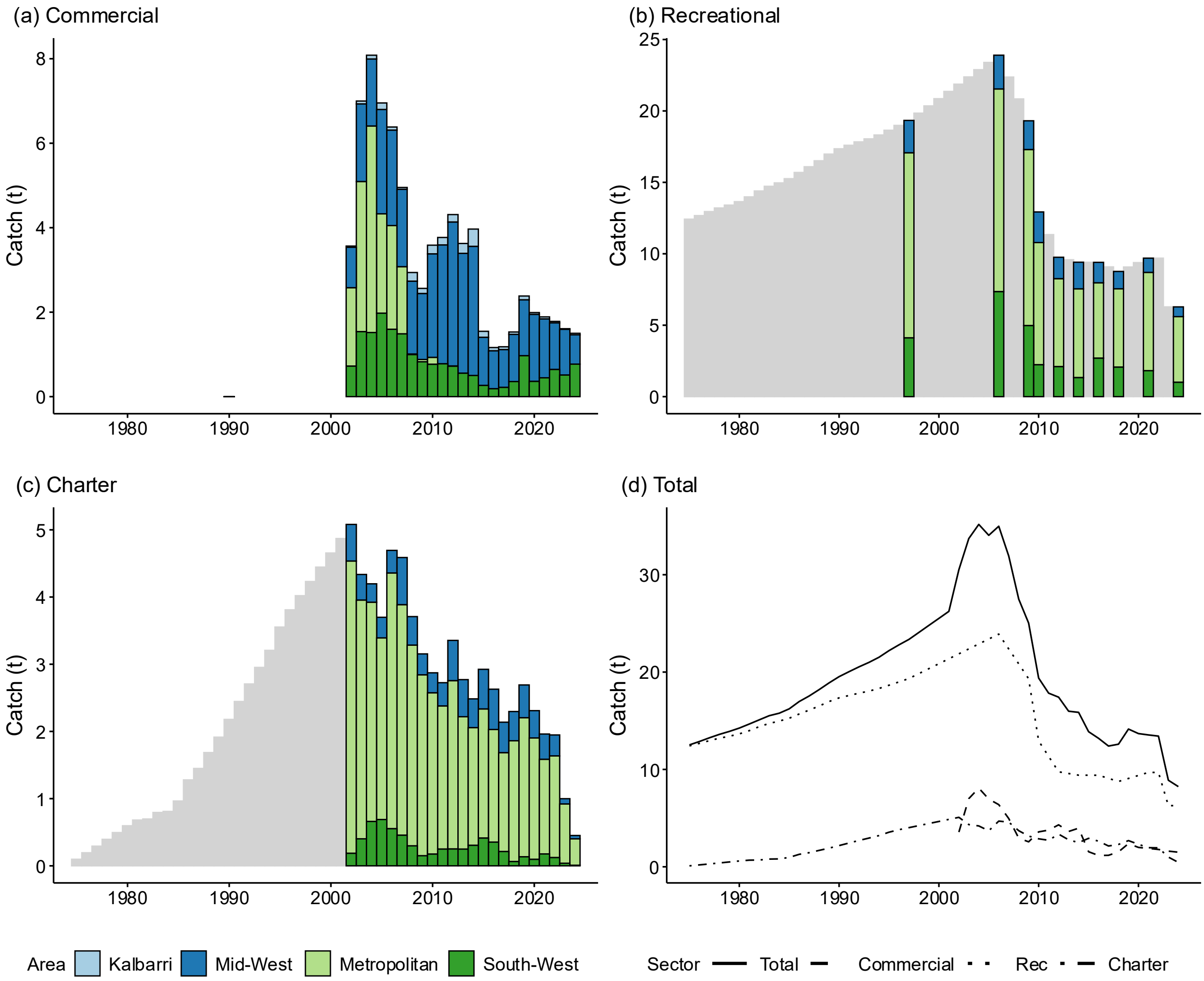


Figure 3.35. Retained catches of Breaksea Cod by (a) commercial, (b) recreational and (c) charter fishers in the WCB since 1975, noting that Kalbarri and Mid-West data are combined for recreational and charter fishers. (d) Total estimated time series of retained catches across all areas of the WCB by each sector.

Logbook data from 2018 to 2022 show that commercial Breaksea Cod catches reported by the WCDSIMF have on average been highest from 10×10 nm blocks in the lower Mid-West management area and in waters off Cape Naturaliste in the South-West (Figure 3.36). In contrast, recent charter catches of this species have been primarily landed in the Metropolitan area and, to a lesser extent, off Jurien Bay in the Mid-West (Figure 3.36).

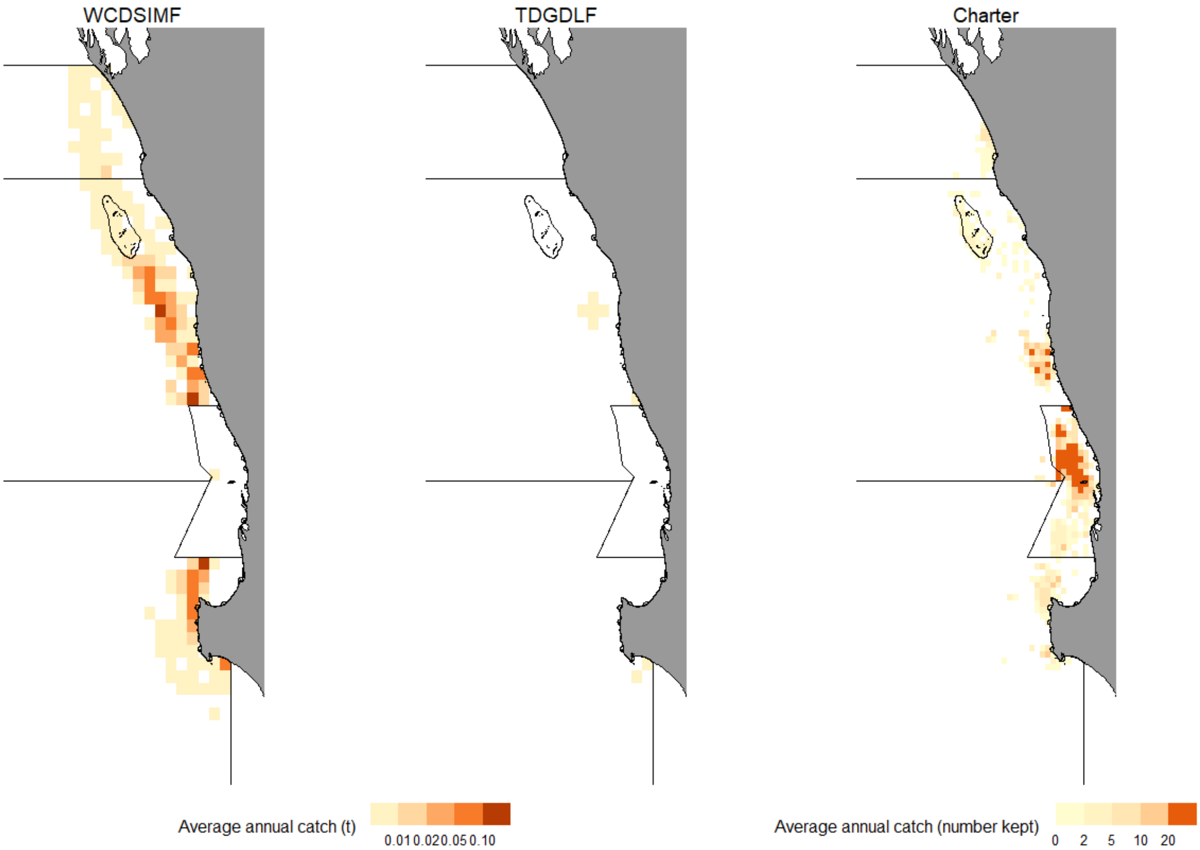


Figure 3.36. Typical distribution of catches of Breaksea Cod in the WCB based on average annual retained catches (2018–2022) across spatial reporting blocks for the WCDSIMF and TDGDLF (10×10 nm blocks) and charter fishers (5×5 nm blocks) in the WCB. Note the differing scales of plots, with commercial catch reported as weight and charter catch as numbers of fish.

3.7.2 Length Compositions

Length compositions of Breaksea Cod (above the previous MLL of 300 mm) retained in the southern (Metropolitan and South-West) management areas of the WCB show slightly larger fish sampled from recreational catches compared to those reported in charter logbooks (Figure 3.37). The charter data indicate a slight declining trend in the median lengths of retained fish over time, while data sampled from recreational catches have remained relatively consistent (Figure 3.37).

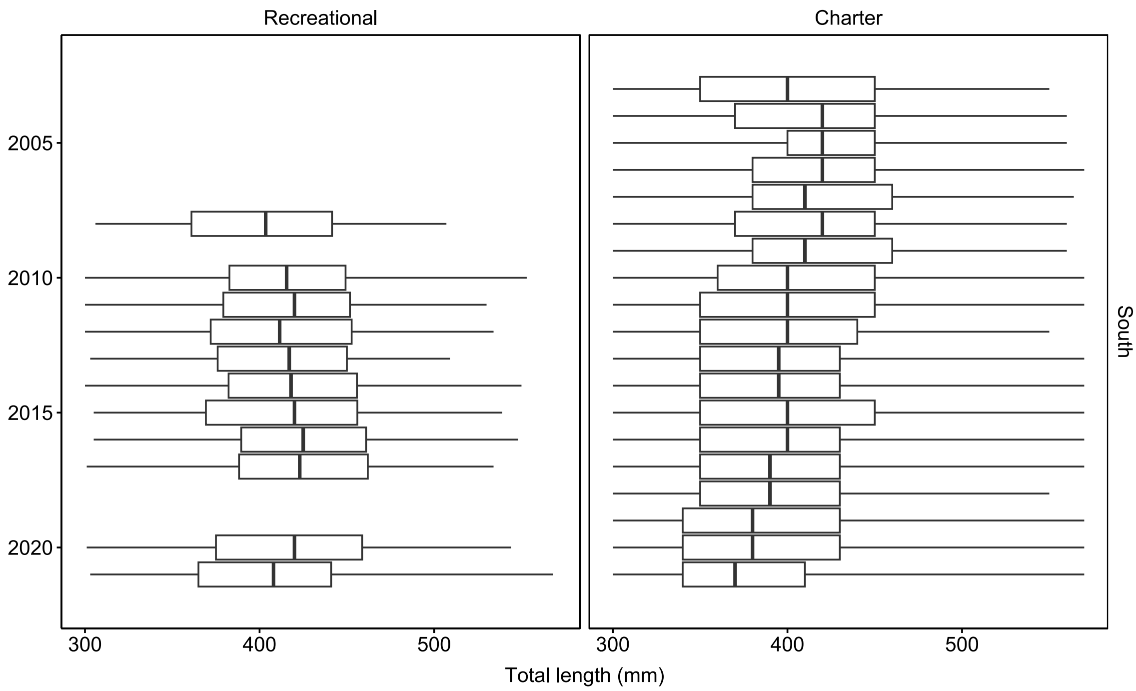


Figure 3.37. Relative length frequencies of Breaksea Cod sampled from recreational and charter catches in the southern (Metropolitan and South-West) management areas of the WCB, grouped by biological years (e.g. 2020 is 1 Feb 2020–31 Jan 2021). The boxes represent the 25th, 50th (median) and 75th percentile of observed lengths, with the horizontal lines extending between the minimum and maximum observed values. Only data from years with sample sizes above 100 fish are shown.

3.7.3 Age Compositions

Age composition data from recreational catches of Breaksea Cod in the southern management areas of the WCB are limited to samples of aged fish caught in 2013-14 and 2014-15. These data indicate that individuals of this species are first recruited into the fishery at ~ 3-4 years of age, with the modal age shifting from 5 years in 2013-14 to 6 years in 2014-15, possibly indicative of a stronger than average cohort spawned in the late 2000s (Figure 3.38). The range of ages sampled was relatively consistent across the two years with fish as old as 14 and 15 years represented in the data (Figure 3.38).

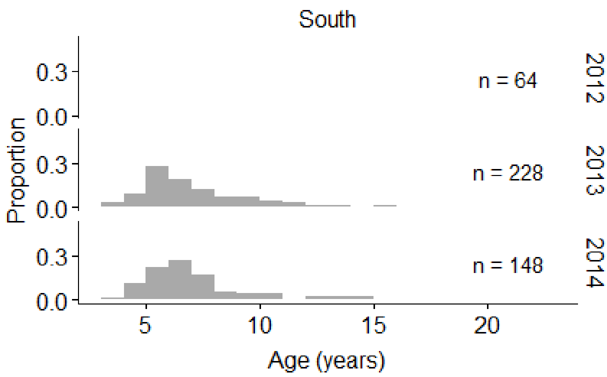


Figure 3.38. Relative age frequencies of Breaksea Cod sampled from recreational catches in the southern (Metropolitan and South-West) management areas of the WCB, grouped by biological years (e.g. 2020 is 1 Feb 2020–31 Jan 2021). Note only data from years with sample sizes above 100 fish are presented.

3.7.4 Environmental Impacts

Projected increases in water temperature and more frequent marine heatwaves may lead to a southward shift in the distribution of this temperate species. Projections of a weaker Leeuwin Current could lead to greater retention of eggs and larvae in the South-west, however, overall impacts on the broader stock across southern WA are uncertain. Based on their biological attributes, Breaksea Cod have a medium sensitivity to climate change.

3.7.5 Model Assessment

3.7.5.1 Level 3 Assessment

Based on the age composition data for Breaksea Cod sampled from recreational catches in the southern (Metropolitan and South-West) management areas of the WCB in 2013-14, the long-term *F* for fully selected fish was at the threshold reference level of *M* (0.19 y^{-1}; Table 3.7). Separate *F* estimates based on data from the Metropolitan and South-West management areas were very similar (~ 0.2 y^{-1}).

The B_{rel} was estimated for female Breaksea Cod in the southern WCB using an equilibrium biomass model that incorporates a stock-recruitment relationship (steepness set to 0.75) and accounts for PRM (50%) of released undersized fish, as 0.43 (Table 3.7), i.e., between the threshold and target reference levels of 0.3 and 0.5, respectively.

Table 3.7. Catch curve estimates of long-term average *F* (y^{-1}, ±95% CI) and equilibrium biomass analysis estimates of female relative spawning biomass (B_{rel} ±95% CI) for Breaksea Cod based on age composition data collected from recreational catches in the southern (Metropolitan and South-West) management areas of the WCB in 2013-14. Point estimates were compared to reference levels, where orange denotes *F* between the threshold and limit level of *M* and 1.5*M* (0.19 and 0.29 y^{-1}, respectively) and yellow denotes B_{rel} between the threshold and target levels of 0.3 and 0.5, respectively.

Area	*F* (±95% CI)	Female B_{rel} (±95% CI)
South	0.19 (0.14-0.25)	0.43 (0.34-0.50)

3.7.6 Risk-based Weight of Evidence Assessment

Category	Line of Evidence
Catch	Annual retained catches of Breaksea Cod in the WCB have reduced markedly since the start of the recovery period in 2010, after peaking ~ 30 t in the mid-2000s. The total retained catch in 2024 was 8 t, of which more than 80% was landed by the recreational sector.
Level 1 Assessment The lower catch level observed since the start of the recovery period is indicative of a reduced fishing pressure on this stock.	
Length Composition	Annual length compositions of Breaksea Cod retained by recreational and charter fishers in the southern WCB have remained relatively stable over time, with recreational fisher landing larger individuals than those reported by charter fishers.

Age Composition	Age composition data sampled from recreational catches of Breaksea Cod in the southern WCB in 2013-14 and 2014-15 were relatively consistent and included fish as old as 15 years.
Equilibrium Biomass Model	Based on age composition data collected in 2013-14, the estimated long-term *F* of fully selected Breaksea Cod in the southern WCB was at the threshold level of 0.19 y^{-1}. The corresponding equilibrium biomass model estimate of female B_{rel} of 0.43 (95%CI = 0.34-0.50) was between the threshold and target reference levels of 0.3 and 0.5, respectively.
Level 3 Assessment Consistent with lower catch levels since the start of the recovery period, equilibrium-based (Level 3) model estimates of *F* and B_{rel} are indicative of reduced fishing pressure on the stock, which was not overfished at the time of sampling (2013-14). The results should be interpreted with caution due to the equilibrium assumptions of the models used.	
Environmental Impact	Warming water temperatures may lead to a southward shift in the distribution of Breaksea Cod. Based on their biological attributes, they have a medium sensitivity to climate change.
Risk Assessment C1 Minor (Above Target): Although the upper 95% CI of the estimated female B_{rel} in 2013-14 was at the target level of 0.5, the likelihood of minor depletion is assessed as Unlikely (5-20%). C2 Moderate (Above Threshold, below Target): The estimated female B_{rel} and the associated 95% CI in 2013-14 were between the threshold and target levels of 0.3 and 0.5, respectively, with management actions taken to recover the WCDSR successfully maintaining catches of this species at a relatively stable, low level over recent years. The likelihood of moderate depletion is assessed as Likely (>50%). C3 High (Above Limit, below Threshold): The likelihood of high depletion is assessed as Remote (<5%). C4 Major (Below Limit): The likelihood of major depletion is assessed as Remote (<5%). Based on the risk matrix below, the overall risk to Breaksea Cod in the southern (Metropolitan and South-West) management areas of the WCB is assessed as **Medium** (C2 × L4).	

Consequence (Stock level)	Likelihood			
	1 Remote (<5%)	2 Unlikely (5-20%)	3 Possible (20-50%)	4 Likely (>50%)
1 Minor (above Target)		X		
2 Moderate (between Target and Threshold)				Medium
3 High (between Threshold and Limit)	X			
4 Major (below Limit)	X			

3.7.7 Assessment Advice

Although uncertain, this equilibrium-based (Level 3) assessment of Breaksea Cod in the southern WCB indicate a Medium (Adequate) risk to the stock. As the recovery plan in place for the WCDSR is focused on the highest-risk stocks (Snapper and WA Dhufish), recent management measures taken to reduce fishing pressure on the resource are expected to also benefit Breaksea Cod.

3.8 Hapuku

3.8.1 Catch

Commercial catches of Hapuku in the WCB were first reported around 1990 have fluctuated markedly between years as a result of changes in targeting of this deeper-water species (Figure 3.39). Annual commercial catches, which have been primarily landed in the South-West management area, have typically exceeded 15 t in in one or two years each decade, interspersed with lower catch years with < 5 t retained (Figure 3.39). Charter and recreational catches of Hapuku have only been recorded in the WCB in more recent years, with annual catches of 0.5–3 t retained in the Metropolitan and South-West management areas (Figure 3.39). In 2024, the total retained catch of Hapuku in the WCB was 4 t, of which more than 90% was landed by the commercial sector.

Logbook data from 2018-2022 show that commercial WCDSIMF catches of Hapuku have mostly been retained from offshore waters of the South-West, with 10×10 nm blocks with higher average catches relatively widely distributed across this area (Figure 3.40). Over the same time period, the minor charter catches of this species have been recorded in only a small number of 5×5 nm reporting blocks off the northern Metropolitan area and Cape Naturaliste (Figure 3.40).

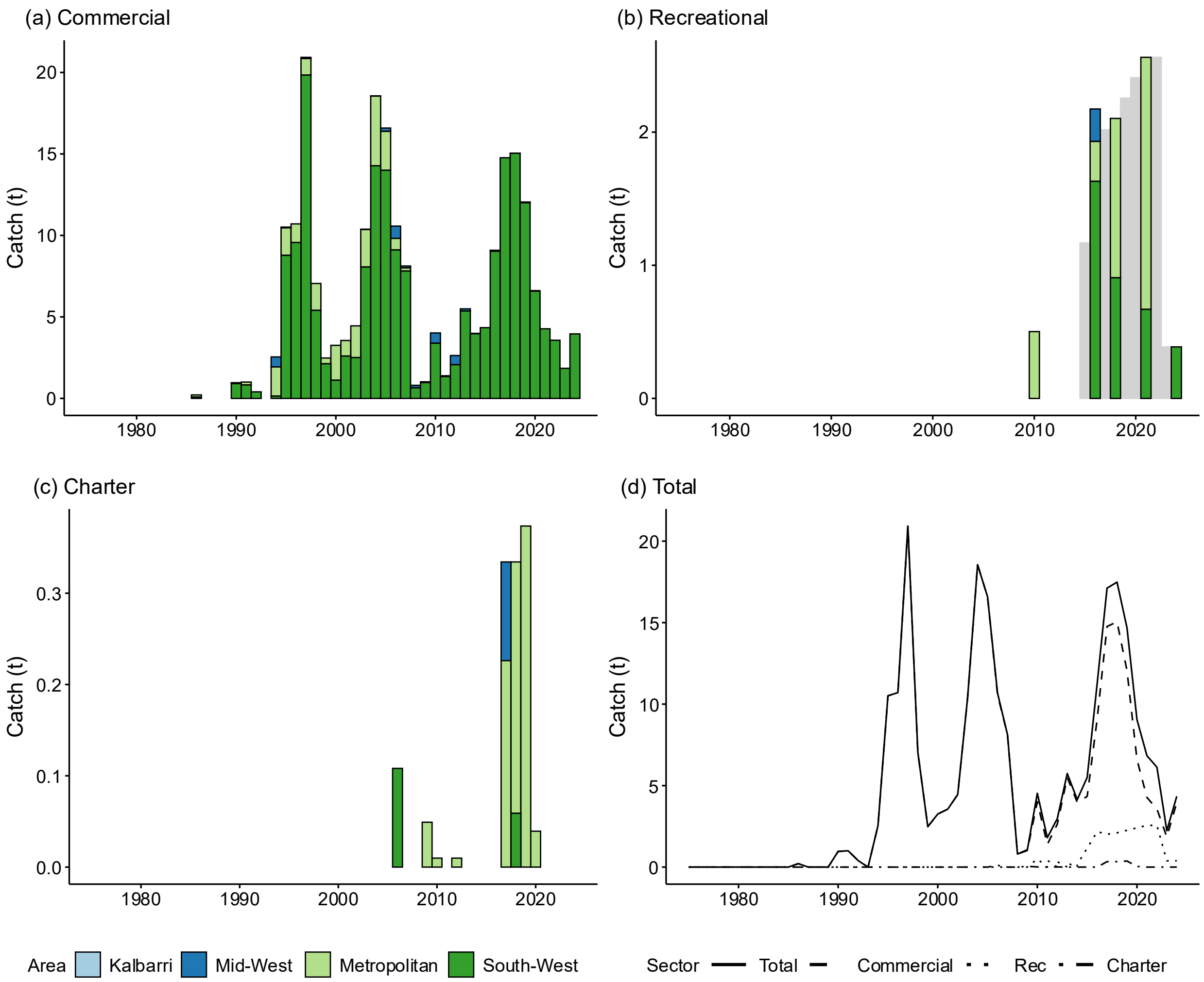


Figure 3.39. Retained catches of Hapuku by (a) commercial, (b) recreational and (c) charter fishers in the WCB since 1975. (d) Total estimated time series of retained catches across all areas of the WCB by each sector.

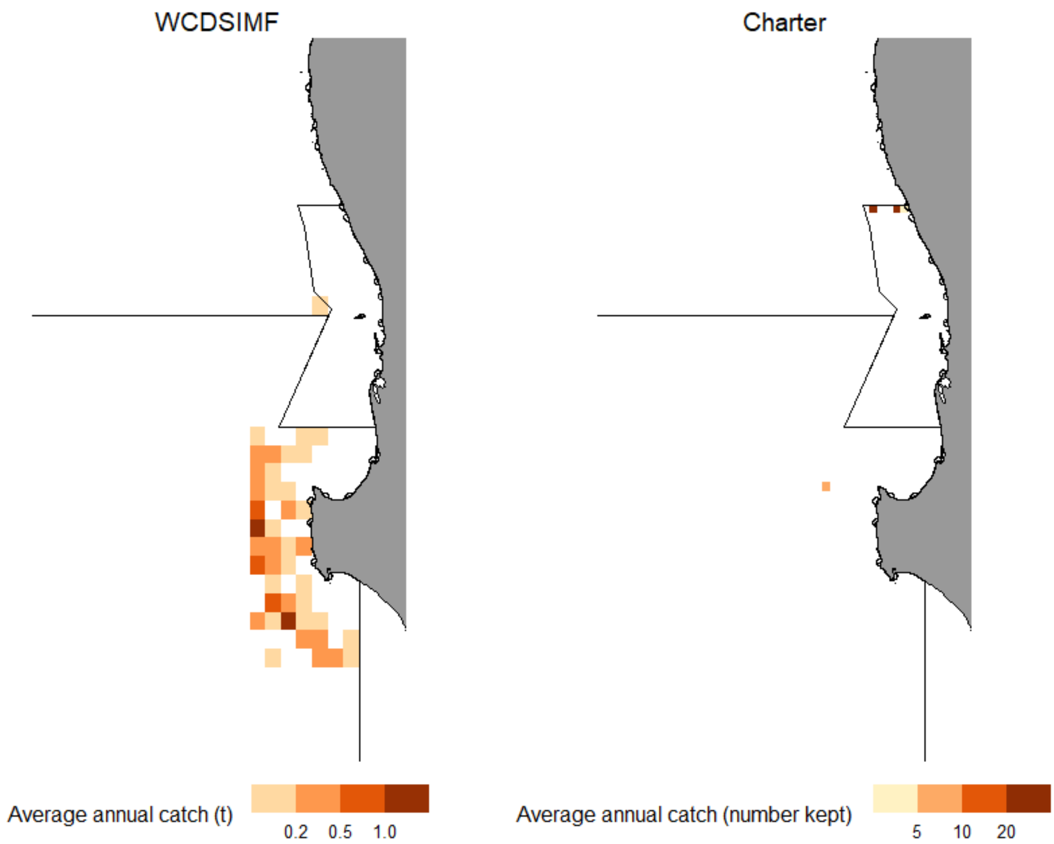


Figure 3.40. Typical distribution of catches of Hapuku in the WCB based on average annual retained catches (2018–2022) across spatial reporting blocks for the commercial WCDSIMF (10×10 nm blocks) and charter fishers (5×5 nm blocks) in the southern WCB. Note the differing scales of plots, with commercial catch reported as weight and charter catch as numbers of fish.

3.8.2 Environmental Impacts

Although a deeper-water species, Hapuku has an extended pelagic juvenile phase and could be impacted by increasing water temperatures while inhabiting the upper parts of the water column, particularly at this northern extent of its distribution. Based on their biological attributes, Hapuku have a medium sensitivity to climate change.

3.8.3 Model Assessment

3.8.3.1 Level 1 Assessment

While highly uncertain and based only on catch information and assumptions regarding stock productivity (r = 0.1–0.6) and estimates of initial and final levels of depletion (0.8–1 and 0.3–0.9, respectively), Catch-MSY analyses for Hapuku predicts a MSY of 10 t (95% CI = 6–17 t) for the WCB (Figure 3.41). As annual catches have fluctuated below and within this estimated range, outputs are indicative of sustainable exploitation levels of this species to date (Figure 3.41).

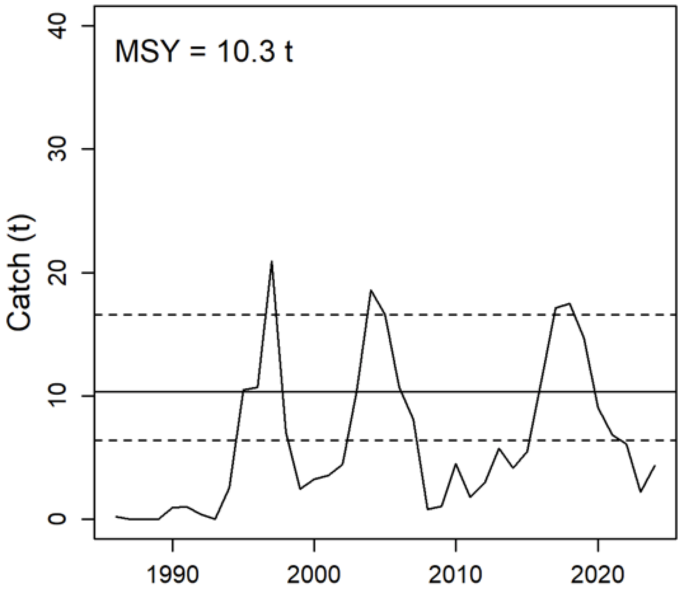


Figure 3.41. Annual retained caches of Hapuku in the WCB, relative to the estimated Maximum Sustainable Yield (MSY; solid horizontal line) and associated 95% CI (dashed lines).

3.8.4 Risk-based Weight of Evidence Assessment

Category	Line of Evidence
Catch	Annual retained catches of Hapuku in the WCB have fluctuated markedly (up to 20 t) since it was first reported by commercial fishers targeting deeper-water species around 1990. The total retained catch in 2024 was 4 t, of which more than 90% was landed by the commercial sector.
Catch-MSY Model	Although outputs are highly uncertain, Catch-MSY analysis indicates that catches of Hapuku in the WCB have broadly fluctuated around and below the estimated MSY of 10 t.
Level 1 Assessment Although catches have fluctuated widely over time, they have mostly been maintained below and around the estimated MSY, which indicates that the stock has not been experiencing overfishing.	
Environmental Impact	Warming water temperatures could impact the extended pelagic juvenile phase of Hapuku. Based on their biological attributes, they have a medium sensitivity to climate change.

Risk Assessment

C1 Minor (Above Target): As catches have fluctuated below and around the estimated MSY, the likelihood of minor depletion is assessed as Unlikely (5-20%).

C2 Moderate (Above Threshold, below Target): As catches have fluctuated below and around the estimated MSY, the likelihood of moderate depletion is assessed as Likely (>50%).

C3 High (Above Limit, below Threshold): As catches have fluctuated below and around the estimated MSY, the likelihood of high depletion is assessed as Unlikely (5-20%).

C4 Major (Below Limit): The likelihood of major depletion is assessed as Remote (<5%).

Based on the risk matrix below, the overall risk to Hapuku in the WCB is assessed as **Medium** (C2 × L4).

Consequence (Stock level)	Likelihood			
	1 Remote (<5%)	2 Unlikely (5-20%)	3 Possible (20-50%)	4 Likely (>50%)
1 Minor (above Target)		X		
2 Moderate (between Target and Threshold)				Medium
3 High (between Threshold and Limit)		X		
4 Major (below Limit)	X			

3.8.5 Assessment Advice

Although highly uncertain, this (catch-only) assessment of Hapuku in the WCB indicate a Medium (Adequate) risk. As the recovery plan in place for the WCDSR is focused on the highest-risk stocks, recent management measures taken to reduce fishing pressure on the resource are expected to also benefit Hapuku.

3.9 Bass Groper

3.9.1 Catch

Commercial catches of Bass Groper in the WCB were first reported in the early 2000s as deeper-water habitats were first explored by fishers. The annual commercial catch of this species peaked above 12 t in 2005, landed across the Mid-West, Metropolitan and South-West management areas (Figure 3.42). Since the introduction of the WCDSIMF in 2008, commercial catches of Bass Groper (primarily landed in the South-West) have mostly fluctuated below 2 t annually. Charter and recreational fishing for offshore demersal have only been recorded in recent years, with peaks in Bass Groper catch reported (in the Mid-West and Metropolitan area) by charter fishers (~ 2 t) and private recreational fishers (~ 3 t) around 2017-18 (Figure 3.42). In 2024, the total retained catch of Bass Groper in the WCB was 0.7 t, of which ~ 80% was landed by the recreational sector.

Logbook data show that the low catches of Bass Groper retained by commercial WCDSIMF vessels between 2018 and 2022 were primarily taken across the South-West and in a small cluster of 10x10 nm reporting blocks off Jurien Bay (Figure 3.43). Similar to Hapuku, recent catches of Bass Groper by charter fishers have mostly been taken from a small number of 5×5 nm reporting blocks off the northern Metropolitan area (Figure 3.43).

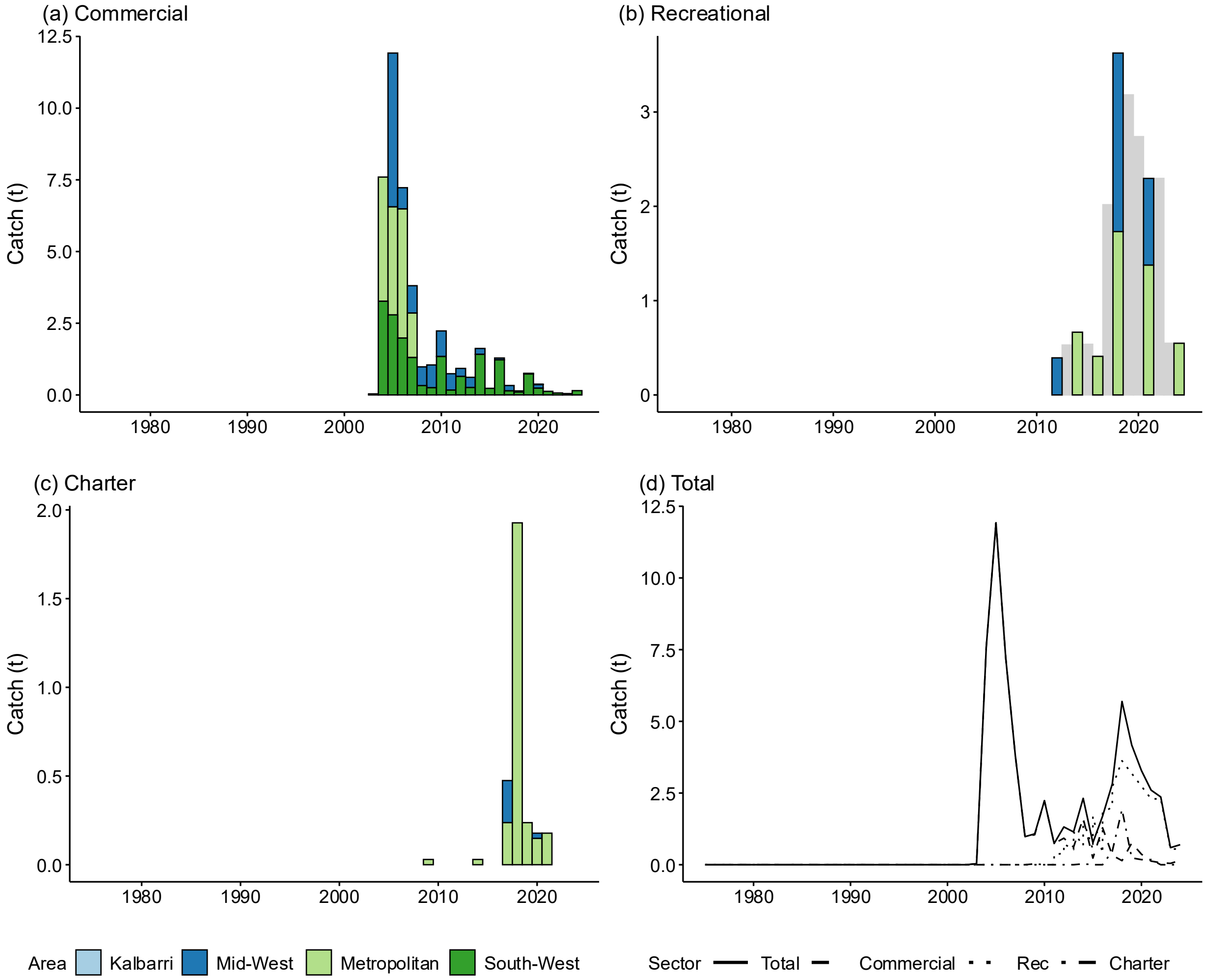


Figure 3.42. Retained catches of Bass Groper by (a) commercial, (b) recreational and (c) charter fishers in the WCB since 1975. (d) Total estimated time series of retained catches across all areas of the WCB by each sector.

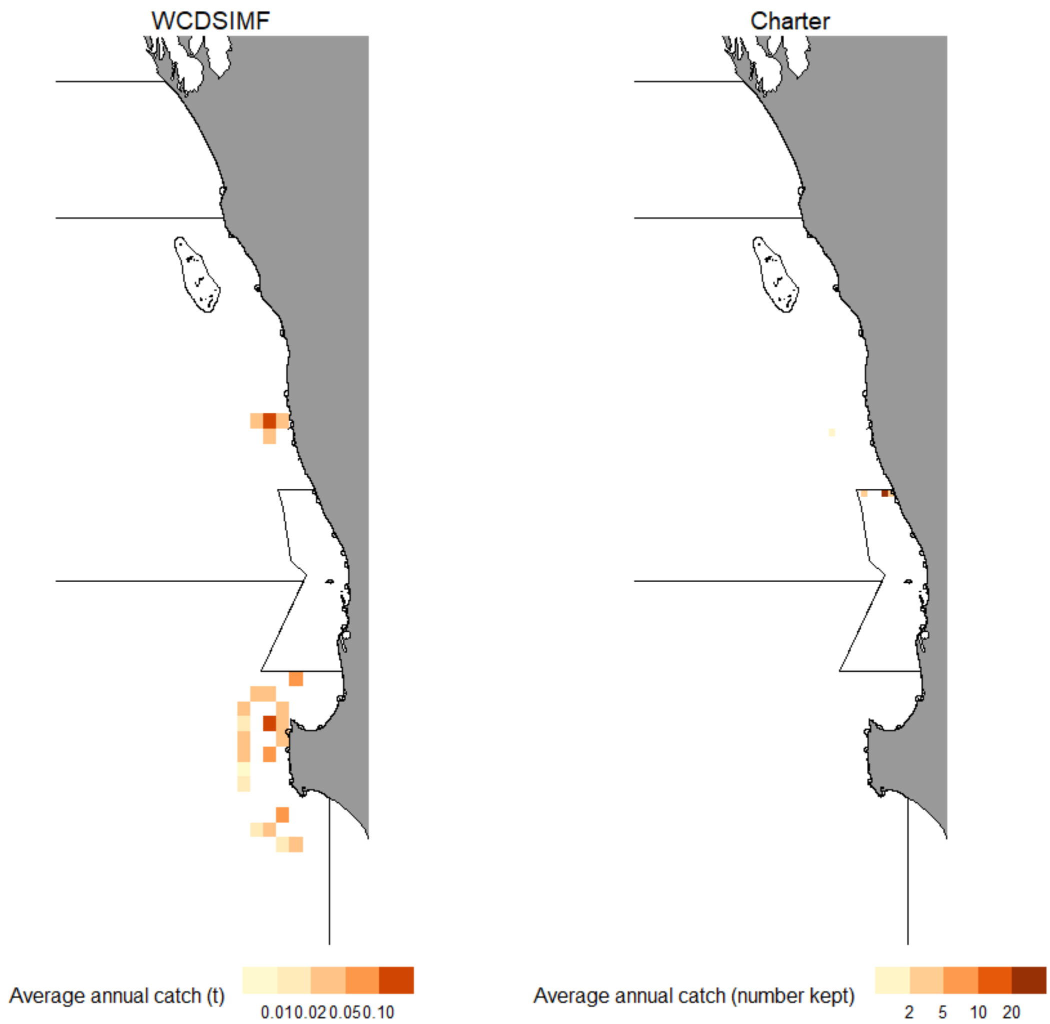


Figure 3.43. Typical distribution of catches of Bass Groper in the WCB based on average annual retained catches (2018–2022) across spatial reporting blocks for the commercial WCDSIMF (10×10 nm blocks) and charter fishers (5×5 nm blocks) in the WCB. Note the differing scales of plots, with commercial catch reported as weight and charter catch as numbers of fish.

3.9.2 Environmental Impacts

Although a deeper-water species, Bass Groper has an extended pelagic juvenile phase of 5 years and could be impacted by increasing water temperatures while inhabiting the upper parts of the water column, particularly at this northern extent of its distribution. Based on their biological attributes, Bass Groper have a medium sensitivity to climate change.

3.9.3 Model Assessment

3.9.3.1 Level 1 Assessment

While highly uncertain and based only on available catch information and assumptions regarding stock productivity (r = 0.1–0.6) and estimates of initial and final levels of depletion (0.8–1 and 0.3–0.9, respectively), Catch-MSY analyses for Bass Groper predicts a MSY of 4 t (95% CI = 2–6 t) for the WCB (Figure 3.44). Although the annual catch substantially exceeded the estimate MSY in 2005, recent catches have been maintained within or below this estimated range (Figure 3.44).

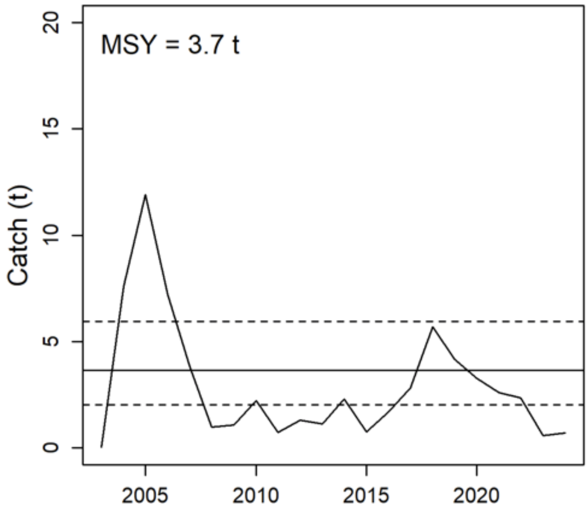


Figure 3.44. Annual retained caches of Bass Groper in the WCB, relative to the estimated Maximum Sustainable Yield (MSY; solid horizontal line) and associated 95% CI (dashed lines).

3.9.4 Risk-based Weight of Evidence Assessment

Category	Line of Evidence
Catch	Annual retained catches of Bass Groper in the WCB peaked ~ 12 t in the mid-2000s, with a recent shift in the proportions of catch landed by the commercial and recreational sectors. The total retained catch in 2024 was 0.7 t, of which ~ 80% was landed by the recreational sector.
Catch-MSY Model	Although outputs are highly uncertain, Catch-MSY analysis indicates that catches Bass Groper in the WCB have mostly fluctuated around and below the estimated MSY of 4 t.
Level 1 Assessment As catches have mostly fluctuated below and around the estimated MSY, this indicates that the stock has not been experiencing overfishing.	
Environmental Impact	Warming water temperatures could impact the extended pelagic juvenile phase of Bass Groper. Based on their biological attributes, they have a medium sensitivity to climate change.

Risk Assessment

C1 Minor (Above Target): As catches have fluctuated below and around the estimated MSY, the likelihood of minor depletion is assessed as Possible (20-50%).

C2 Moderate (Above Threshold, below Target): As catches have fluctuated below and around the estimated MSY, the likelihood of moderate depletion is assessed as Possible (20-50%).

C3 High (Above Limit, below Threshold): As catch data suggest the species has not been consistently targeted by fishers over the recent decades, the likelihood of high depletion is assessed as Remote (<5%).

C4 Major (Below Limit): Based on available catch information, the likelihood of major depletion is assessed as Remote (<5%).

Based on the risk matrix below, the overall risk to Bass Groper in the WCB is assessed as **Medium** (C2 × L3).

	Likelihood			
Consequence (Stock level)	1 Remote (<5%)	2 Unlikely (5-20%)	3 Possible (20-50%)	4 Likely (>50%)
1 Minor (above Target)			X	
2 Moderate (between Target and Threshold)			Medium	
3 High (between Threshold and Limit)	X			
4 Major (below Limit)	X			

3.9.5 Assessment Advice

Although highly uncertain, this (catch-only) assessment of Bass Groper in the WCB indicate a Medium (Adequate) risk. As the recovery plan in place for the WCDSR is focused on the highest-risk stocks, recent management measures taken to reduce fishing pressure on the resource are expected to also benefit Bass Groper.

3.10 Blue-eye Trevalla

3.10.1 Catch

Commercial catch data indicates that Blue-eye Trevalla was first targeted in the WCB in the mid-1990s, with substantial catches landed across the Mid-West, Metropolitan and South-West management areas in most years of the 2000s (Figure 3.45). As with Bass Groper, the annual commercial catch peaked in 2005 (at 15 t) and has mostly fluctuated below 2 t since the introduction of the WCDSIMF in 2008 (Figure 3.45). Charter and recreational catches of Blue-eye Trevalla in the WCB have largely been limited to the last 5-10 years and have primarily been landed in the Metropolitan area (Figure 3.45). Charter fishers reported annual catches of 2 t in 2017 and 2018, before catches reduced to very low levels. Catches by private recreational fishers in the WCB gradually increased from <1 t in 2013-14 to 3 t in 2020-21, with no catches reported in 2023-24 (Ryan et al. 2025). In 2024, the total retained catch of Blue-eye Trevalla in the WCB was 0.8 t, of which ~ 80% was landed by the commercial sector.

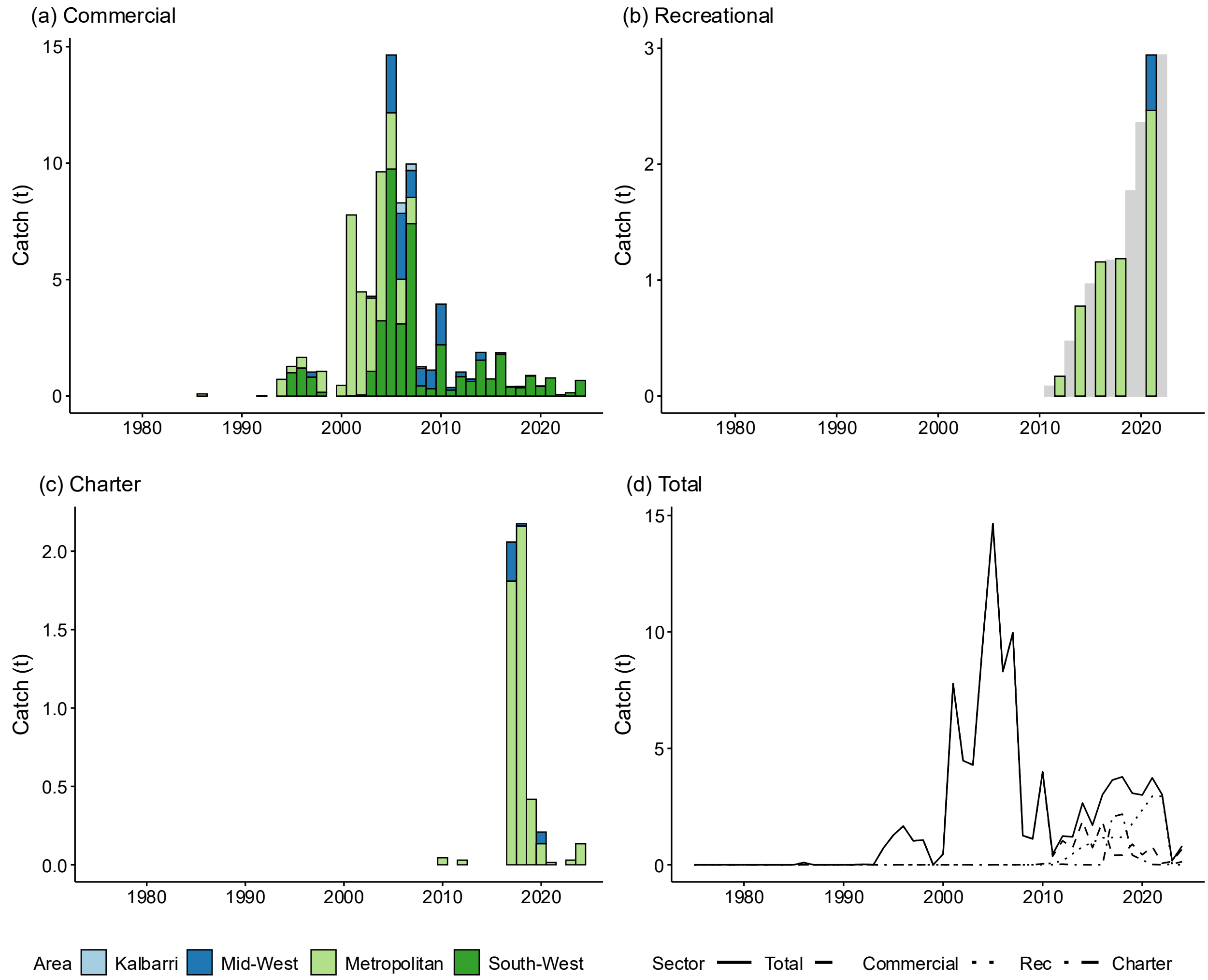


Figure 3.45. Retained catches of Blue-eye Trevalla by (a) commercial, (b) recreational and (c) charter fishers in the WCB since 1975. (d) Total estimated time series of retained catches across all areas of the WCB by each sector.

Logbook data show that commercial WCDSIMF catches of Blue-eye Trevalla between 2018 and 2022 were mostly taken from waters off the Capes region in the South-West area of the WCB, with lower commercial and charter catches retained from a small number of reporting blocks across the Kalbarri, Mid-West and Metropolitan management areas (Figure 3.46).

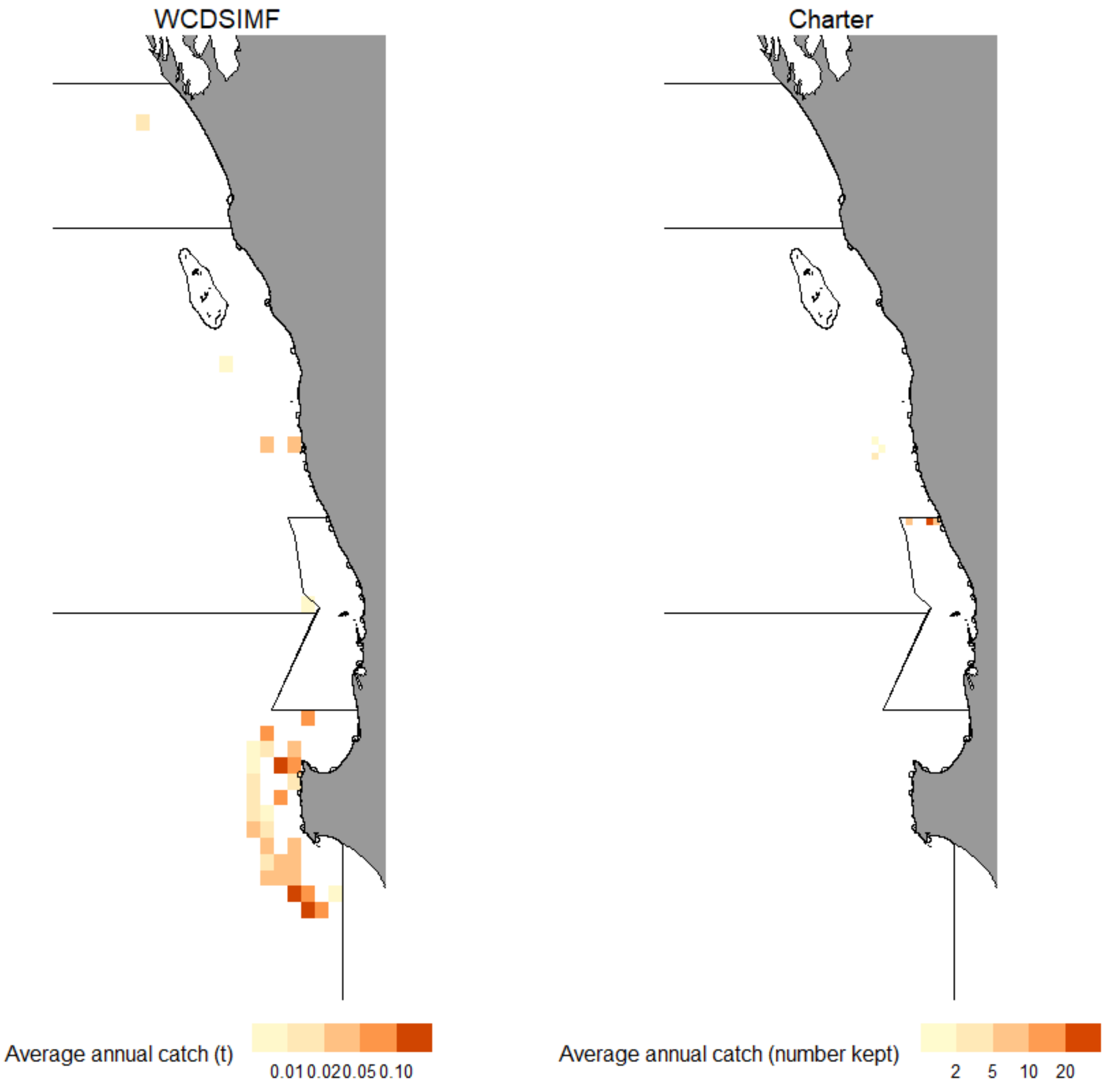


Figure 3.46. Typical distribution of catches of Blue-eye Trevalla in the WCB based on average annual retained catches (2018–2022) across spatial reporting blocks for the commercial WCDSIMF (10×10 nm blocks) and charter fishers (5×5 nm blocks) in the WCB. Note the differing scales of plots, with commercial catch reported as weight and charter catch as numbers of fish.

3.10.2 Environmental Impacts

Although a deeper-water species, it has an extended pelagic juvenile phase of 2 years and could be impacted by increasing warming waters while inhabiting the upper parts of the water column, particularly at this northern extent of its distribution. Based on their biological attributes, Blue-eye Trevalla have a low sensitivity to climate change.

3.10.3 Model Assessment

3.10.3.1 Level 1 Assessment

While highly uncertain and based only on available catch information and assumptions regarding stock productivity (*r* = 0.1–0.6) and estimates of initial and final levels of depletion (0.8–1 and 0.3–0.9, respectively), Catch-MSY analyses for Blue-eye Trevalla predicts a MSY of 5 t (95% CI = 3–7 t) for the WCB (Figure 3.47). Although the annual catch substantially exceeded the estimate MSY in 2005, recent catches have been maintained within or below this estimated range (Figure 3.47).

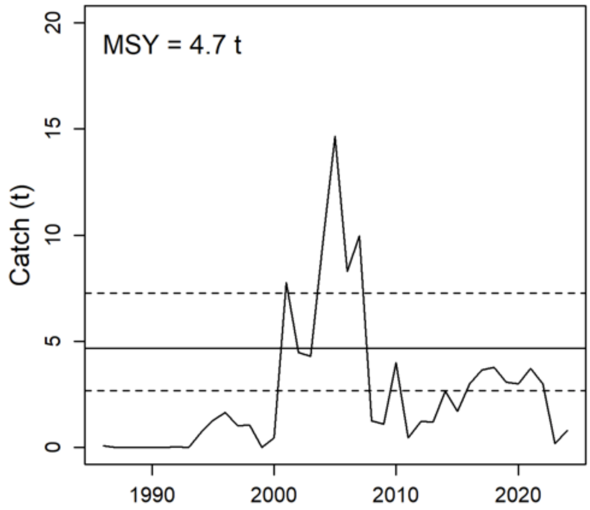


Figure 3.47. Annual retained caches of Blue-eye Trevalla in the WCB, relative to the estimated Maximum Sustainable Yield (MSY; solid horizontal line) and associated 95% CI (dashed lines).

3.10.4 Risk-based Weight of Evidence Assessment

Category	Line of Evidence
Catch	Annual retained catches of Blue-eye Trevalla in the WCB peaked ~ 15 t in the mid-2000s, with recent shifts in the proportions of catch landed by the commercial and recreational sectors. The total retained catch in 2020-21 was 0.8 t, of which ~ 80% was landed by the commercial sector.
Catch-MSY Model	Although outputs are highly uncertain, Catch-MSY analysis indicates that catches of Blue-eye Trevalla in the WCB have mostly fluctuated around and below the estimated MSY of 5.5 t.
Level 1 Assessment As recent catches have fluctuated below the estimated MSY, this indicates that the stock has not been experiencing overfishing.	
Environmental Impact	Warming water temperatures could impact the extended pelagic juvenile phase of Blue-eye Trevalla. Based on their biological attributes, they have a low sensitivity to climate change.

Risk Assessment

C1 Minor (Above Target): As catches have mostly fluctuated around and below the estimated MSY, the likelihood of minor depletion is assessed as Possible (20-50%).

C2 Moderate (Above Threshold, below Target): As catches have mostly fluctuated around and below the estimated MSY, the likelihood of moderate depletion is assessed as Possible (20-50%).

C3 High (Above Limit, below Threshold): As the species has not been consistently targeted by fishers, the likelihood of high depletion is assessed as Remote (<5%).

C4 Major (Below Limit): The likelihood of major depletion is assessed as Remote (<5%).

Based on the risk matrix below, the overall risk to Blue-eye Trevalla in the WCB is assessed as **Medium** (C2 × L3).

Consequence (Stock level)	Likelihood			
	1 Remote (<5%)	2 Unlikely (5-20%)	3 Possible (20-50%)	4 Likely (>50%)
1 Minor (above Target)			X	
2 Moderate (between Target and Threshold)			Medium	
3 High (between Threshold and Limit)	X			
4 Major (below Limit)	X			

3.10.5 Assessment Advice

Although highly uncertain, this (catch-only) assessment of Blue-eye Trevalla in the WCB indicate a Medium (Adequate) risk. As the recovery plan in place for the WCDSR is focused on the highest-risk stocks, recent management measures taken to reduce fishing pressure on the resource are expected to also benefit Blue-eye Trevalla.

4 Ecological Assessment

An Ecological Risk Assessment (ERA) is due to be undertaken for the southern demersal scalefish fisheries, including those targeting the WCDSR. The current risk to ecological components other than the target stocks of the WCDSR are reviewed annually as part of the Department's annual Status Reports of the Fisheries and Aquatic Resources of Western Australia (State of the Fisheries; e.g., Newman et al. 2024).

4.1 Other Retained Species

Line fishing for demersal species using baited hooks is highly selective for fishes, with catches of species other than the key species only retained in relatively low numbers. As management measures implemented to recover the broader WCDSR are likely to have provided benefits to these minor retained species, the risk to these species is assessed **Medium**.

4.2 Bycatch Species

Line fishing for demersal species using baited hooks is highly selective for fishes. While other fishes that are caught but not normally retained during demersal fishing activities (including inedible species, e.g., silver toadfish, and small species, such as wrasses) may not all survive, the risk to these bycatch species is assessed as **Low**.

4.3 ETP Species

Mandatory reporting of listed species interactions by commercial WCDSIMF and charter fishers suggest these interactions are relatively rare. In 2022-23, the charter sector caught and released alive one potato cod. The risk to listed species is assessed as **Negligible**.

4.4 Habitats

Line fishing is the main method used in the commercial and recreational fishery for demersal species. As this fishing method has limited physical impact on the benthic environment, the risk to benthic habitats is assessed as **Negligible**.

4.5 Ecosystem

Changes observed by Hall and Wise (2011) in the catch composition of commercial wetline, gillnet, and longline fisheries in the WCB over a 30-year timeline may be a result of changes in targeting or improvements in reporting methods. As there has been no evidence of a decline in the trophic level or mean size of catches, the risk to the ecosystem is assessed as **Low**.

4.6 Assessment Advice

In line with the WCDSR Harvest Strategy, management should continue to focus on meeting objectives relating to the sustainability of target stocks.

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Appendix 1: Assessment Description

Level 1 Assessment

Trends in catch over time provide important inputs to the assessment of each key demersal species in the WCB and can be important for understanding changes in fishery dynamics and recruitment of key stocks. Analyses of commercial and charter catch information also consider the spatial extent of catches (by reporting blocks) and how these change over time.

Demersal scalefish catches by commercial fishers are reported in weight (kg), while recreational and charter catches are reported in numbers. To monitor the overall demersal scalefish catch in the WCB, annual retained catches of key species, or groups of species, by charter and recreational fishers are converted to weight using available length and weight information. Length-weight relationships for the key species (e.g., Smallwood et al. 2018) are applied to calculate average weights from the lengths of retained fish derived from charter logbooks and recreational boat-ramp surveys. Annual catches of each key species are then calculated from the number of retained fish in each year and the estimated average weights of those fish. Where the annual average weight is based on less than 100 fish, the long-term average weight is applied using all available data for the species. As long-term average weights are updated when new data become available, annual charter and recreational catches can vary slightly between reporting years.

As required for assessments of key demersal species in the WCB, available data on charter catches since 2002 and periodic survey estimates of boat-based recreational catches since the mid-1990s have been used to derive time series of retained catches going back to 1975. To reconstruct charter and recreational catches for each inshore demersal species, the following process has been applied:

1. Extrapolating charter catches between 1975 and 2002, based on the proportional increase in the number of charter vessels operating in the WCB over this period (Tour Operator’s Fishing Working Group 1998).
2. Adjusting estimates of private boat-based recreational catches from early creel surveys (+30%) to account for fishing that was out of scope in these surveys (Crowe et al. 2013).
3. Extrapolating private boat-based recreational catches prior to between 1975 and 1997, based on annual percentage change in the estimated residential population in WA from the Australian Bureau of Statistics.
4. Linearly interpolating private boat-based recreational catches between survey years, with catches in 2022 assumed to have remained the same since the 2020-21 survey and catches in 2023 and 2024 informed by the 2023-24 survey (i.e., the change is aligned to the 2023 changes in management).

Note that for offshore demersal species such as Bass grouper and Blue-eye Trevalla, which have only been targeted by the recreational sector in recent years, charter and recreational data were not extrapolated back prior to the first year of recorded catch (i.e., only the fourth business rule was applied).

Catch-MSY Model

For each offshore demersal species for which biological age and length composition data have not been sampled to date in the WCB, available catch time series data were analysed using a Catch-MSY simulation approach (Haddon et al. 2019). This method is applied to catch data for stocks, incorporating (strong) assumptions about its productivity and carrying capacity (specified ranges for *r* and *K*, respectively) as well as specified ranges for initial and final depletion levels (0.8–1 and 0.3–0.9, respectively, for each offshore species). Although outputs of this simulation analysis are considered highly uncertain, comparing observed annual catches with the predicted MSY from this analysis can be informative for assessing whether the stock is/has been heavily exploited.

Level 2 Assessment

Catch and effort data from commercial line fishing have been used to calculate standardised catch per unit effort (CPUE) time series for the assessments of Snapper and WA Dhufish in the WCB. For each species, separate CPUE standardisation analyses have been undertaken using handline and dropline data from the northern (Kalbarri and Mid-West) and southern (Metropolitan and South-West) management areas of the WCB since the mid-1980s. Due to differences in reporting, separate time series of CPUE were calculated from data collected by monthly CAES returns (mid-1980s to 2007), and daily logbooks (since 2008). Note that CPUE time series based on daily logbook data are not available for the Metropolitan area, which was closed to commercial fishing for demersal scalefish in late 2007.

Prior to analyses, the data for each species are thoroughly explored and screened, with some records removed to ensure a more 'balanced' data set, e.g., by limiting the data to include only those vessels that fished consistently over a substantial time period. As Licensed Fishing Boat (LFB) numbers can be transferred between vessels, and vessels can be replaced under the same LFB, vessel names and LFBs were cross-referenced with licensing records to ensure that vessel data related to a unique boat. Similarly, inconsistencies in the format of skipper names reported over time were manually checked.

To overcome the challenge that WCDSIMF effort data cannot be differentiated between species, records indicative of targeted fishing for each species from daily logbook data were identified using a logistic regression approach as described in Stephens and MacCall (2004). This method uses species composition from logbook records to infer whether fishing effort was directed toward suitable habitat for the "target" species, using the fitted regression parameters to estimate the probability that the target species would have been encountered during a fishing event. Only those records with probabilities above a predefined threshold, chosen to minimise the mismatch between observed and expected species presence, were included in the CPUE analysis. This filtering process helps to reduce the influence of non-target effort, thereby improving the accuracy and interpretability of abundance indices.

As monthly logbook records involve a coarser temporal and spatial resolution, and the aggregation of multiple fishing events, the Stephens-MacCall method employed for daily logbooks is not generally appropriate. Targeted fishing from monthly logbook data records was characterised based on a qualification level approach (see Biseau 1998). Specifically, only those records from vessels for which the species being considered for analysis comprised greater than or equal to 90% of the overall catch were retained for analyses. Alternative qualification levels (ranging from 80 to 100%) have been explored and found to have relatively limited influence on the overall CPUE trends.

Although several models have been explored for standardising CPUE for each species, the current adopted approach applies a generalised linear mixed model (GLMM) with the skipper-vessel factor considered as a random effect (Helser et al. 2004). The GLMM accounts for temporal (month) and spatial (latitude and longitude of reporting blocks) effects on data to generate standardised annual time series of CPUE considered suitable for use as indices of abundance for these stocks.

To account for changes in fishing efficiency in the commercial line fishery over time, normalised values of the standardised CPUE indices from both handline and dropline methods have been adjusted by an efficiency schedule as per Marriott et al. (2011). This schedule accounts for fishing efficiency increases associated with adoption of GPS, colour sounders and hydraulic reels between 1975 and 2006 (Marriott et al. 2011). As this schedule has been considered a minimum level of adjustment, additional annual increases in efficiency (e.g., from other changes to technology or fisher experience) have also been accounted for in CPUE indices used in model assessments of Snapper and WA Dhufish. For snapper, additional annual efficiency increases of 2% and 1% for monthly and daily CPUE time series, respectively, were included. For WA Dhufish, adjustments incorporated additional annual efficiency increases of 3% and 1% for monthly and daily CPUE time series, respectively (Fairclough et al. 2021). While the magnitude of these additional changes in fishing efficiency are uncertain, sensitivity analyses undertaken using the integrated assessment models for Snapper and WA Dhufish showed that removing these additional adjustments to the monthly CPUE time series had limited impact on estimates of current stock status (see Appendix 3).

A discrete, state-space version of the Schaefer biomass dynamics model with an annual time step, developed for the study of Marks et al. (2021), was fitted to catch data and standardised (adjusted) CPUE time series for Snapper and WA Dhufish in the 2021 assessment (Fairclough et al. 2021). As outputs were highly uncertain due to lack of signal (i.e. one way trip) in the available abundance indices, this analysis was not repeated for the most recent (2024) assessment.

Level 3 Assessment

Catch Curve Analyses

For each key species, estimates of the (long-term average) instantaneous rate of total mortality (Z, y^{-1}) were derived from age composition data using catch curve analyses. Estimates of fishing mortality (F) were then calculated by subtracting the estimated value of natural mortality (M) for each species/stock (see Fisher & Fairclough 2024) from each catch curve estimate of Z, i.e., $F = Z – M$. Given the equilibrium assumptions common to catch curve models, it is important to emphasise that these F estimates represent the long-term, average F experienced by fully-selected fish in the population.

Several catch curve models have been applied to explore the extent to which model assumptions and uncertainty impact on demersal scalefish assessment results (Fairclough et al. 2014; Norriss et al. 2016). The primary catch curve method used in recent Level 3 assessments of key WCDSR species is fitted simultaneously to consecutive years of age composition data to account for variability in annual recruitment. This age-based, multi-year catch curve model provides estimates of F, age-based logistic selectivity parameters and annual recruitment deviations. The model assumes a prior for the natural logarithm of the standard deviation of recruitment of 0.6. A full mathematical description of this catch curve model was provided by Fairclough et al. (2014).

For each species, the catch curve model was fitted to age composition data collected at the stock level and/or (where relevant) for individual management areas in the WCB where sample sizes were sufficiently large across each of the three- or four-year sampling periods. Although separate catch curves have previously been fitted to data collected from the commercial and recreational sectors in the Mid-West area (Fairclough et al. 2021), for recent analyses, these data were pooled given the lack of marked differences in the estimated gear selectivity of these sectors. Catch curve models were fitted in AD Model Builder (Fournier et al. 2012), with outputs analysed and plotted using the software R (R Core Team 2023; see Appendix 2 for model fits). Estimates of *F* were compared to harvest strategy reference levels relating to the value of *M* (DPIRD 2021).

Based on preliminary explorations, catch curve estimates of *F* for WA Dhufish using data from the most recent sampling period were found to be sensitive to the variable modal age of fish between years. While the model provided good visual fits to the data, there appeared to be insufficient information in the data to accurately estimate all model parameters, particularly in areas where data comprised a limited number of age classes. Consequently, to reduce model complexity and possible confounding between model parameters, catch curve analyses using WA Dhufish age data from 2018-22 assumed knife-edge selectivity at age 9 years, set above the A_{95} selectivity estimated from earlier analyses. The most recent estimate of *F* for Bight Redfish in the South-West area was derived from the Chapman & Robson (1960) catch curve mortality estimator, applied to a single year of available data from 2019. For both WA Dhufish and Bight Redfish, equilibrium biomass analyses incorporated recent catch curve estimates of *F* and 'borrowed' information on age-based logistic selectivity parameters from estimates of these using data from the previous sampling period.

Equilibrium Biomass Analyses

Estimates of B_{rel} for key species were derived from an age-based per-recruit model that incorporates a Beverton and Holt stock-recruitment relationship (with the steepness parameter *h* set to 0.75) to account for expected impacts of fishing on recruitment. While analyses are subject to several of the (equilibrium) assumptions that also apply to catch curve analyses, per-recruit analyses incorporate additional knowledge of key biological characteristics of a fish stock, such as growth, maturity and selectivity. The model included separate logistic curves to describe the age-based gear selectivity and age-based retention of fish (above their MLL) to account for PRM (see DPIRD 2021 for PRM levels of each species). For the protogynous Baldchin Groper and Redthroat Emperor, the per-recruit model also allowed for the female-to-male sex change.

The catch curve and equilibrium biomass analyses were undertaken in R (R Core Team 2023) using the L3Assess package (Hesp 2023, see vignette for full model description). The model was specified to use an annual timestep and incorporated catch curve estimates of *F* and age-based selectivity (retention) parameters, as well as biological parameters reported for each species by Fisher and Fairclough (2024). Uncertainty around *F*, *M* and *h* were considered by re-sampling 500 normally distributed values of each parameter based on the estimated or specified mean and associated standard deviation, where the latter ranged between 0.025 and 0.1.

Level 5 Assessment

A bespoke age- and sex-structured, two-area dynamic population model was used to provide estimated annual time series of female B_{rel} and *F* for Snapper and WA Dhufish. For each of these two indicator species, the model was fitted using available time series of annual catch data, standardised commercial CPUE data (assumed to represent indices of abundance) and age composition data, which were separated by the northern (Kalbarri and Mid-West) and southern (Metropolitan and South-West) management areas of the WCB to account for relevant spatial stock or population dynamics (see Appendix 2 for model fits). The model also incorporated pre-specified life history parameters to describe growth patterns, weight-at-length relationships and age at maturity of fish, estimated separately for Snapper in the northern and southern WCB, and collectively for WA Dhufish across the WCB (Fisher and Fairclough 2024).

Key features of the model, the pre-specified parameters and input data used for the most recent assessment are presented below, with detailed mathematical descriptions provided in Fairclough et al. (2021).

- The model applied an annual time step. 'Initial conditions' were set according to an initial exploited population at equilibrium, i.e., with specified initial fishing mortality, F_0.
- Values of natural mortality (*M*) were specified (as fixed values) for each species/stock (Fisher & Fairclough 2024).
- The model incorporates a Beverton-Holt stock-recruitment relationship with steepness *h* set to 0.75 (for the base case model). Area-specific log-normal recruitment deviations, with a mean of zero and specified standard deviation of 0.6, were estimated in the model to account for annual variation in recruitment around the values predicted by the stock-recruitment relationship. Recruitment deviations were bias-corrected (associated with back-transformation) in all years except for years prior to recorded annual catches (i.e. model 'burn-in' period) and during the model projection period (and during a few years prior to the projection period, for which the available data were deemed not to be informative for estimating recruitment deviations, based on model diagnostic outputs).
- A feature of the (two-area) models for each species, important for interpreting outputs, is that recruitment to each area is calculated based on the estimated biomass in that area, i.e. the model employs area-specific (Beverton-Holt) stock-recruitment curves. As such, the fish in each area are treated, within the model, essentially as separate populations (with few shared model parameters). This model structure allowed the biomass of each species to be easily summed over the two areas (with associated error), as requested by fishery managers. Recent research indicating that Snapper in the northern and southern areas constitute separate populations (Bertram et al. 2022; Jackson et al. 2023) is consistent with the above modelling assumptions. For WA Dhufish, estimated area-specific recruitment pattern deviations differed, indicating relatively limited connectivity between the two areas, likewise broadly consistent with the above model structure.
- Deterministic length-at-age relationships were described by pre-specified Schnute (Snapper) or von Bertalanffy (WA Dhufish) growth curves. As WA Dhufish exhibits evidence of substantial time-varying growth, growth parameters were estimated using a 'year-effects' model, similar to that described by Cottingham et al. 2016), but considering only changes in the growth coefficient (*k*) over time. Note that as the stock has experience heavy depletion, this meant that it was not possible to produce reliable, time-varying, estimates for the asymptotic length parameter (requiring substantial data for large and old fish). An average *k* value, estimated for 2018-21, was used in the integrated model for describing growth in the most recent time period, and during the model projection period. Deterministic relationships to describe the weight-at-age and logistic female maturity-at-age were also specified for each species/stock and were assumed constant for the model period.

- For each species/stock, mortality of discarded undersize fish was modelled using a 'retention-function' approach (e.g. Shertzer et al. 2021). This involved use of an asymptotic logistic curve for gear selectivity (assumed to be common to all fishing sectors), estimated for dhufish using data from research sampling with line fishing methods, during which all fish caught (i.e. all sizes) were retained. Separate (time-varying) logistic retention curves (of legal-sized fish) were estimated within the integrated model, when fitting the model to age composition data sampled from commercial and recreational line catches (see below). As outlined in the WCDSR Harvest Strategy, the proportion of undersize fish that die following capture and release was specified in the model (25% for Snapper and 50% for WA Dhufish (assuming a 50% reduction in releases of small WA Dhufish since the MLL for this species was removed in 2023). Using this approach, the gear selectivity and retention curves are combined to calculate 'selectivity of landings' and 'selectivity of discards' curves. These are then used in calculations to describe age-related fishing mortality associated with fish landings and discards.
- The model incorporated annual time series of retained catches by each fishing fleet (commercial line, recreational and charter line, and commercial gillnet) in each area (northern/southern WCB) from 1975 to 2024. Annual catches for the model projection period (2023 – 2030) were set at alternative levels, including those corresponding to current catches and the updated recovery benchmarks. Fishing mortality was estimated using Newton's iterative method for matching expected catches and observed (for retained fish).
- The model was fitted to annual age composition data sampled from commercial and recreational line catches of each species in each relevant area (northern/southern WCB).
- The model was also fitted to standardised commercial CPUE time series, calculated separately for handline and dropline fishing reported in monthly CAES data and daily logbook data, and adjusted for changes in fishing efficiency. For Snapper, the model was fitted to dropline data only, with available CPUE time series for the southern WCB limited to that based on monthly CAES return data prior to the closure of the Metropolitan area in 2007 (noting the more recent low targeted catches of this species in the South-West). For each CPUE time series fitted by the model, a catchability coefficient *q* was estimated.
- The overall negative log-likelihood (NLL) of the model has contributions associated with a penalty for variation in the annual recruitment deviations, NLL for age composition data, and NLL for the log-transformed CPUE time series.
- The structures of the integrated models for Snapper and WA Dhufish are essentially the same, except that the Snapper model allows for important differences in biology (i.e., growth and maturity) and management (MLL) for this species between the two areas.

The integrated stock assessment model was run using the software package ADMB (Fournier et al. 2012), with annual point estimates and associated 60% and 95% confidence intervals (CI) reported for female B_{rel}, F and recruitment. For each stock, the estimated B_{rel} and F (and associated 60% CI) in 2024 and at the end of the projection period were compared to harvest strategy reference levels to evaluate current status and the probability of the stocks recovering to B_{MSY} by 2030.

For both species, changes to the integrated model and data inputs since the last (2021) assessment included updates to the 'bias correction' calculations to annual recruitment deviations (i.e., no corrections applied to the model burn-in and projections periods). Additionally, the updated models assumed a self-weighting (common to all years) Dirichlet multinomial distribution for age composition data. An external review of several demersal assessment models by Professor André Punt (University of Washington) in 2024 indicated that this approach is better and can improve model fits to CPUE time series, compared with our previous approach of assuming a Dirichlet distribution and estimating year-specific weightings for annual age samples. Other updates to the integrated model assessments included revised estimates of growth parameters for each species:

- For Snapper, the recent assessment was based on updated Schnute curves estimated outside the model using all available length and age data for each sex and separate stock (see Fisher and Fairclough 2024).
- For WA Dhufish, parameters describing the time-varying growth were re-estimated (external to the model) based on updated biological data collected for each sex since the early 2000s in the WCB. Due to low samples sizes for some of the years in the recent sampling period, the average *k* for 2018-21 was applied to model growth in the last six years, as well as for the model projection period.

The 2021 assessment of WA Dhufish, the first for which an integrated assessment model was applied, assumed that recruitment patterns were the same across the WCB (i.e., overall stock level). In the current assessment, the model was modified slightly to allow for separate recruitment deviations to be estimated for the northern and southern WCB. This led to improved model fits to available age composition data.

Note that DPIRD is currently transitioning the integrated model assessments for several resources from using bespoke integrated models (i.e. models such as described above, built 'in-house') to models developed using the now widely employed and thoroughly tested Stock Synthesis (SS) modelling framework, developed by a team of stock assessment experts at the US National Oceanic and Atmospheric Administration (NOAA). Preliminary SS models developed for both Snapper and WA Dhufish have been externally reviewed by Professor André Punt in 2024 and 2025.

Appendix 2: Model Diagnostics

Snapper – North WCB

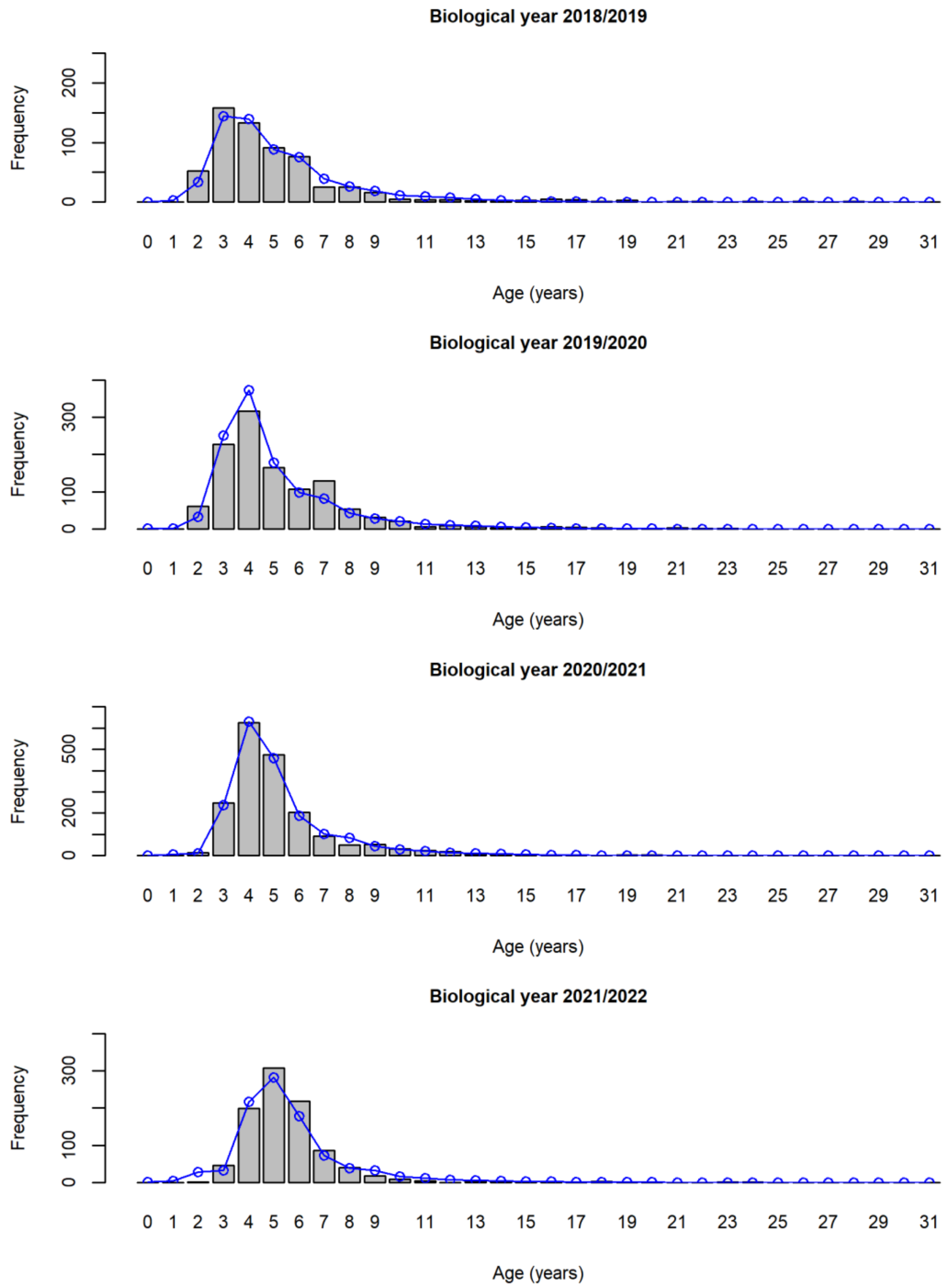


Figure A2.1. Catch curve model fits to age composition data collected from commercial and recreational catches of Snapper in the northern WCB between 2018-19 and 2021-22.

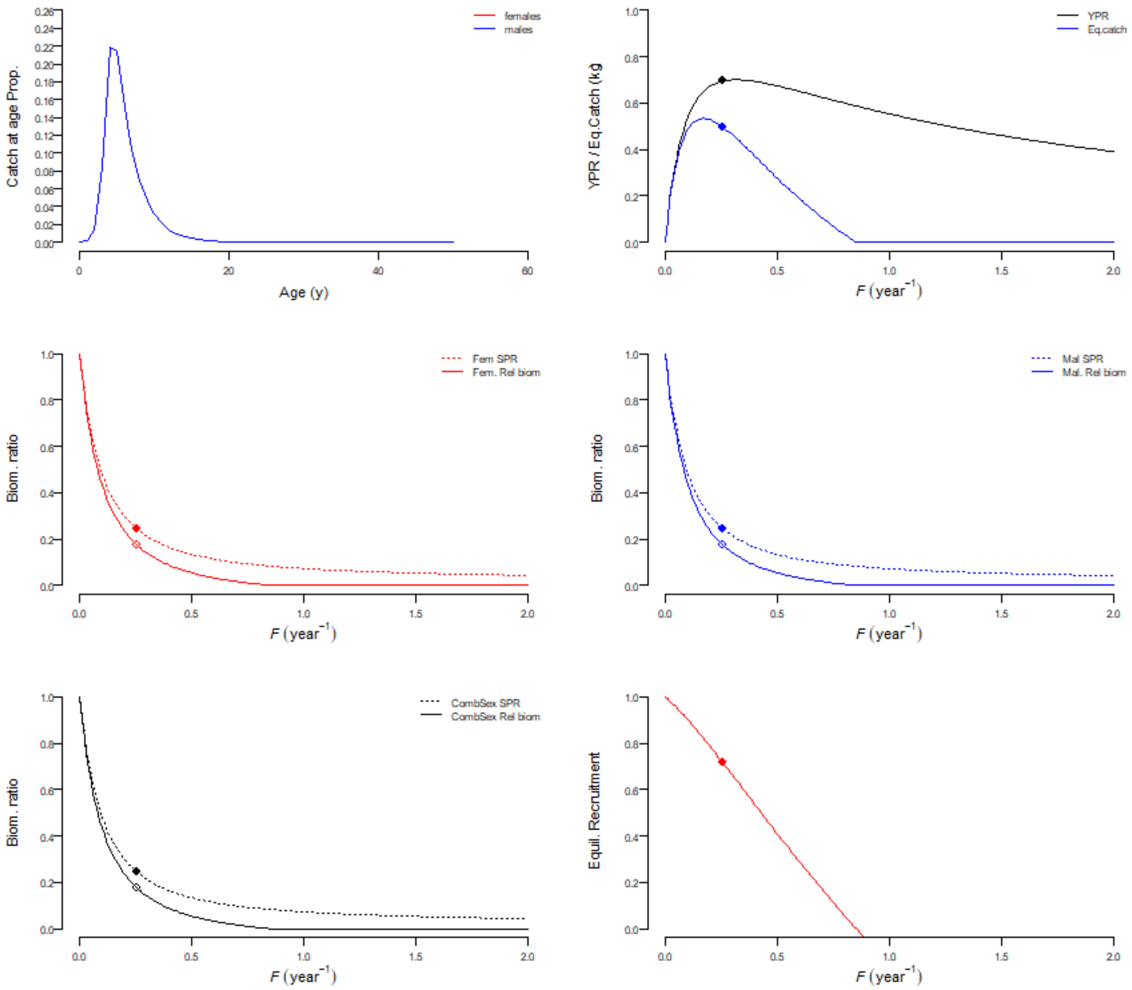


Figure A2.2. Outputs from per-recruit analysis of Snapper in the northern WCB, including the estimated (top left) catch-at-age and relationships between fishing mortality (F; y^{-1}) and (top right) yield-per-recruit/equilibrium catch (kg), spawning potential ratio/relative spawning biomass for (middle left) females, (middle right) males, (bottom left) combined sexes, and (bottom right) equilibrium recruitment. Point estimates correspond to the current estimate of long-term average *F* from catch curve analysis.

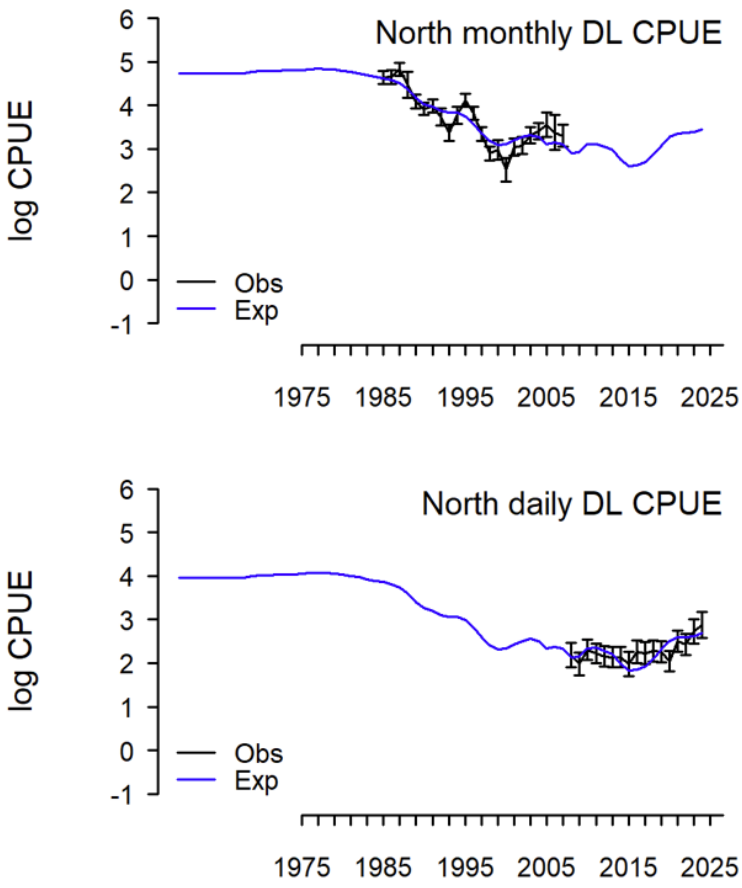
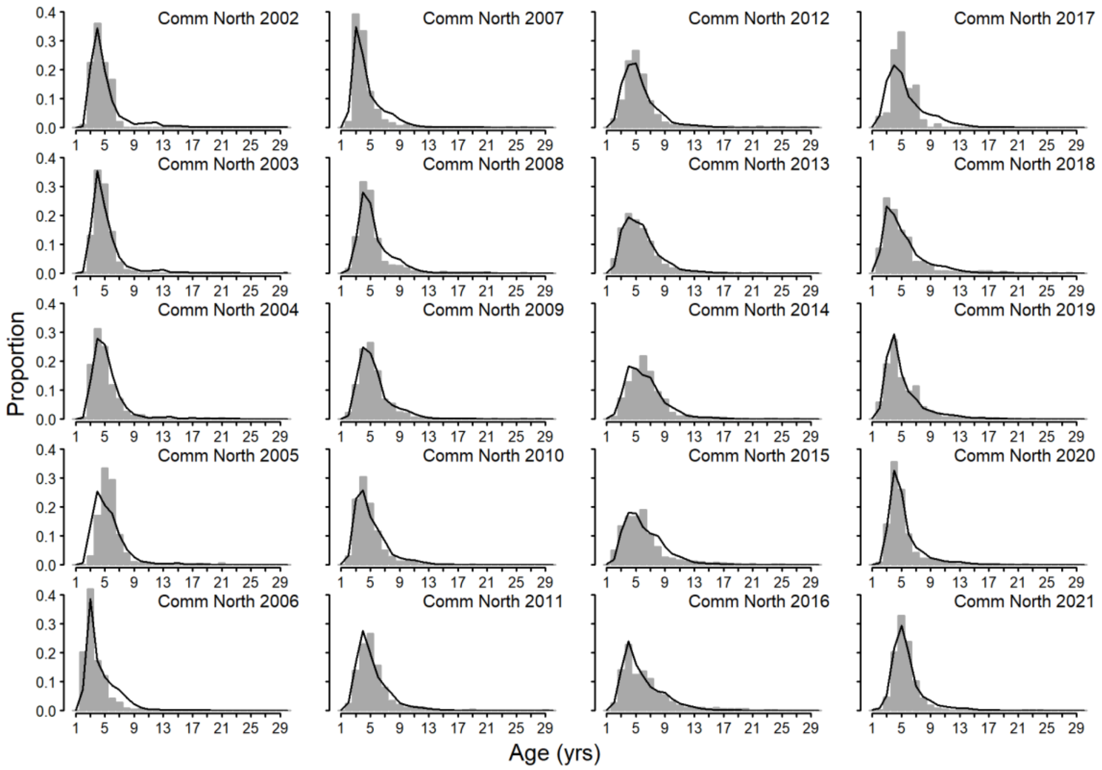


Figure A2.3. Integrated model fits to time series of adjusted standardised CPUE for Snapper in the northern WCB, derived from commercial dropline (DL) data reported in monthly returns and, since 2008, daily logbooks.

(a) Commercial



(b) Recreational

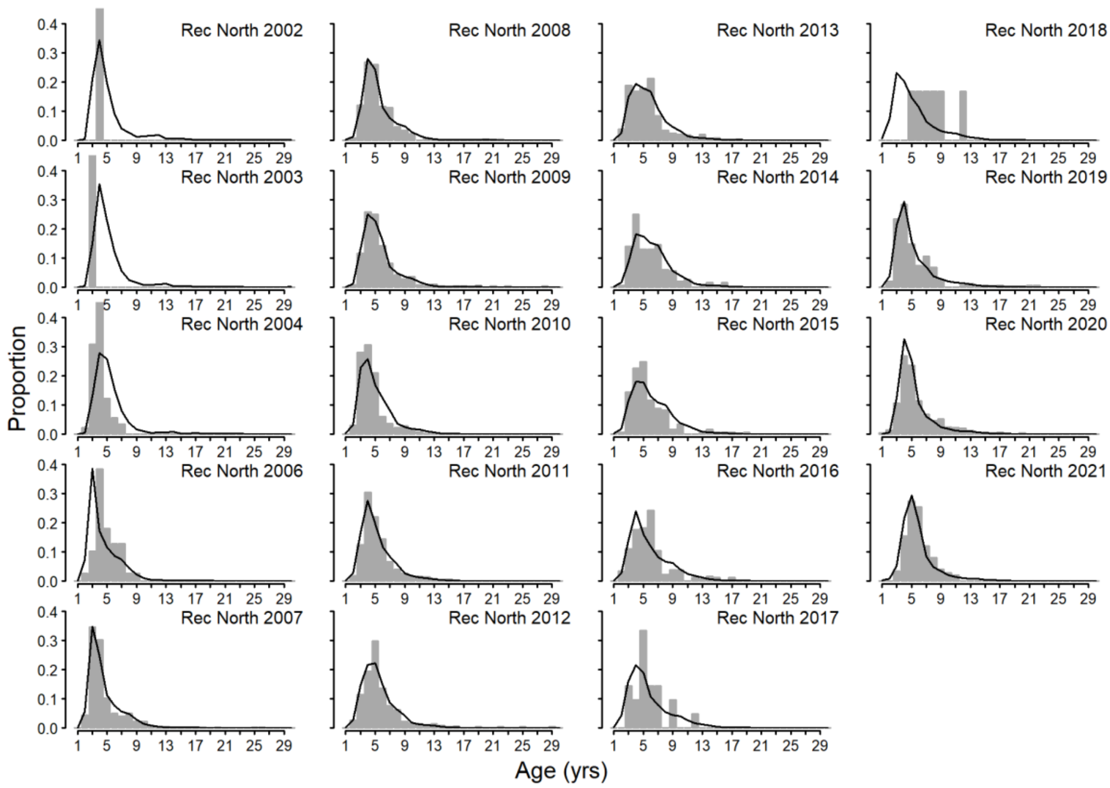


Figure A2.4. Integrated model fits to age composition data collected from (a) commercial and (b) recreational catches of Snapper in the northern WCB.

Snapper – South WCB

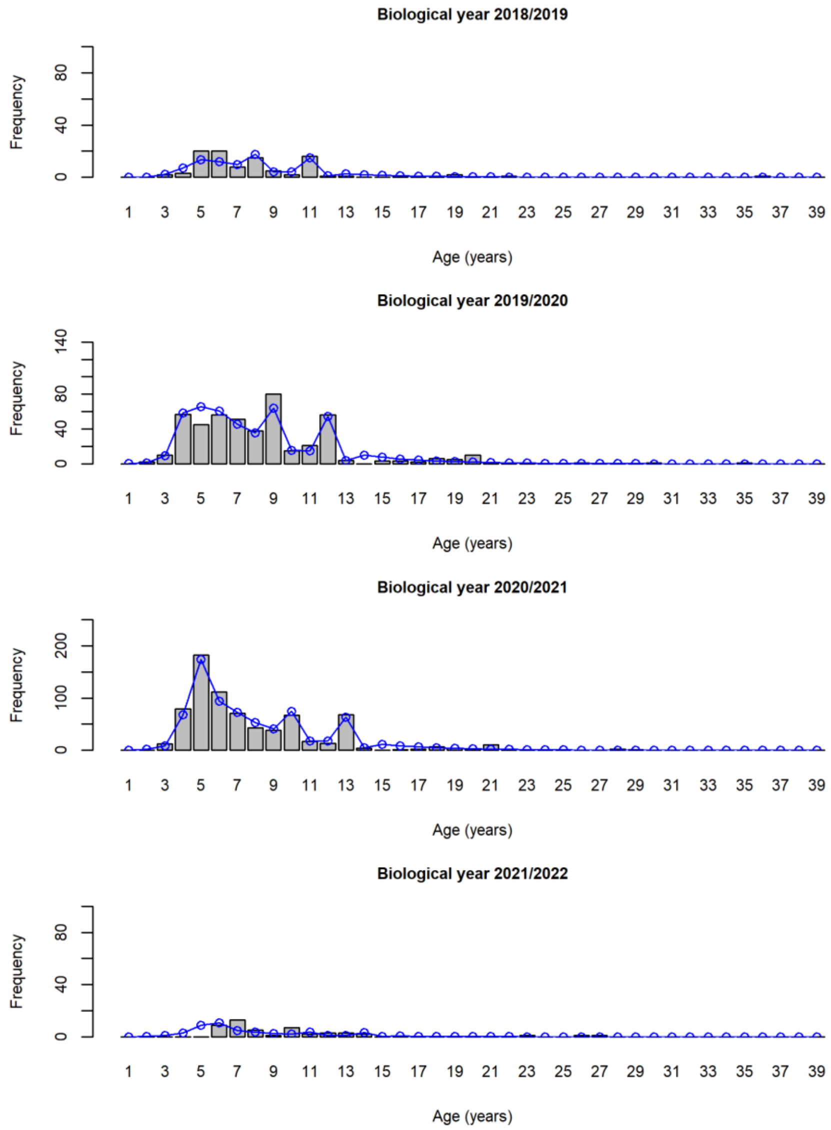


Figure A2.5. Catch curve model fits to age composition data collected from recreational catches of Snapper in the southern WCB between 2018-19 and 2021-22.

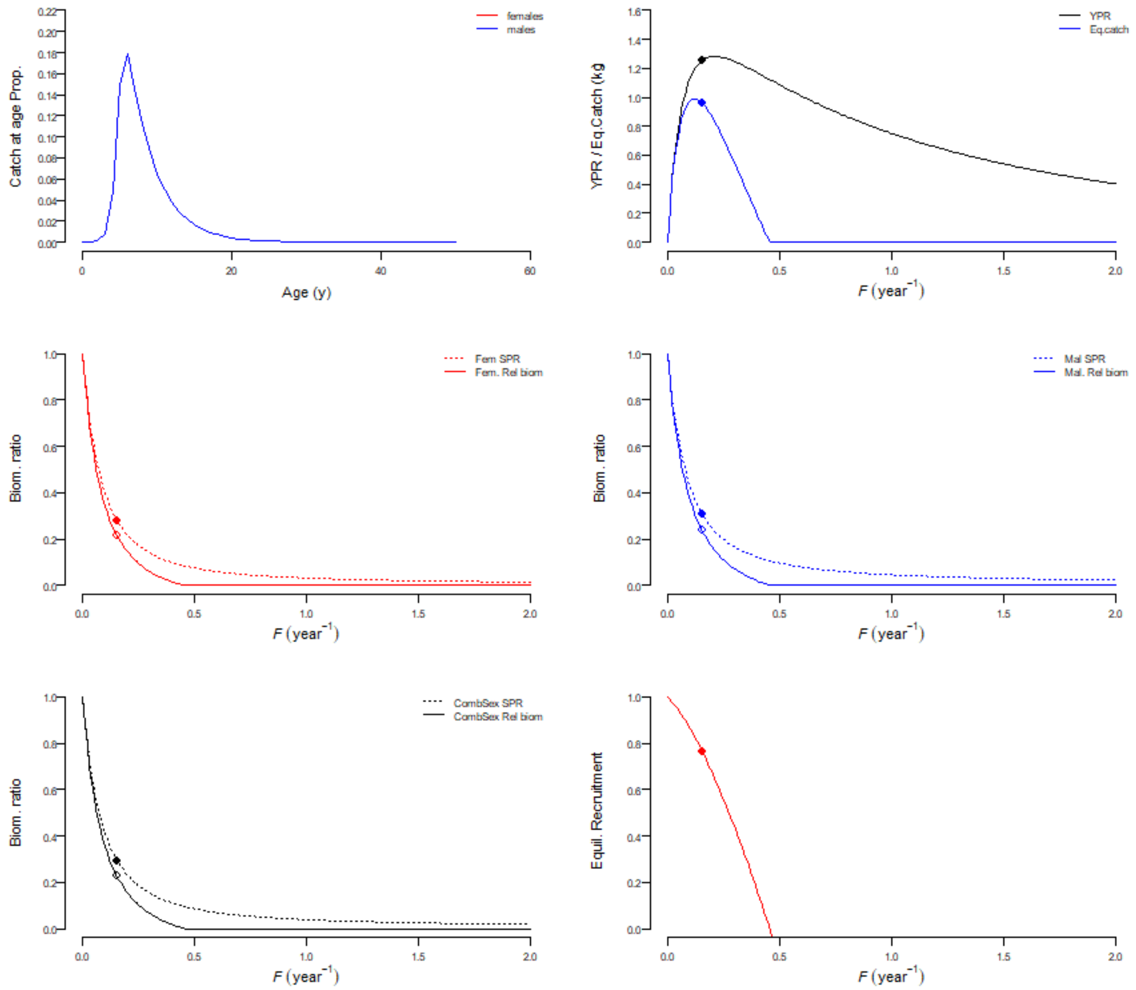


Figure A2.6. Outputs from per-recruit analysis of Snapper in the southern WCB, including the estimated (top left) catch-at-age and relationships between fishing mortality (*F*; y^{-1}) and (top right) yield-per-recruit/equilibrium catch (kg), spawning potential ratio/relative spawning biomass for (middle left) females, (middle right) males, (bottom left) combined sexes, and (bottom right) equilibrium recruitment. Point estimates correspond to the current estimate of long-term average F from catch curve analysis.

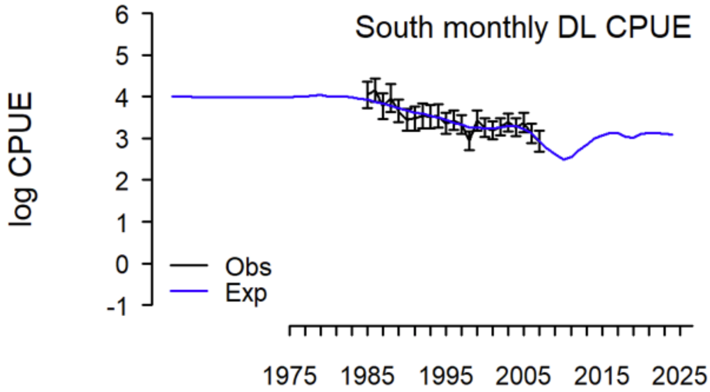


Figure A2.7. Integrated model fits to time series of adjusted standardised CPUE for Snapper in the southern WCB, derived from commercial dropline (DL) data reported in monthly returns (until 2008).

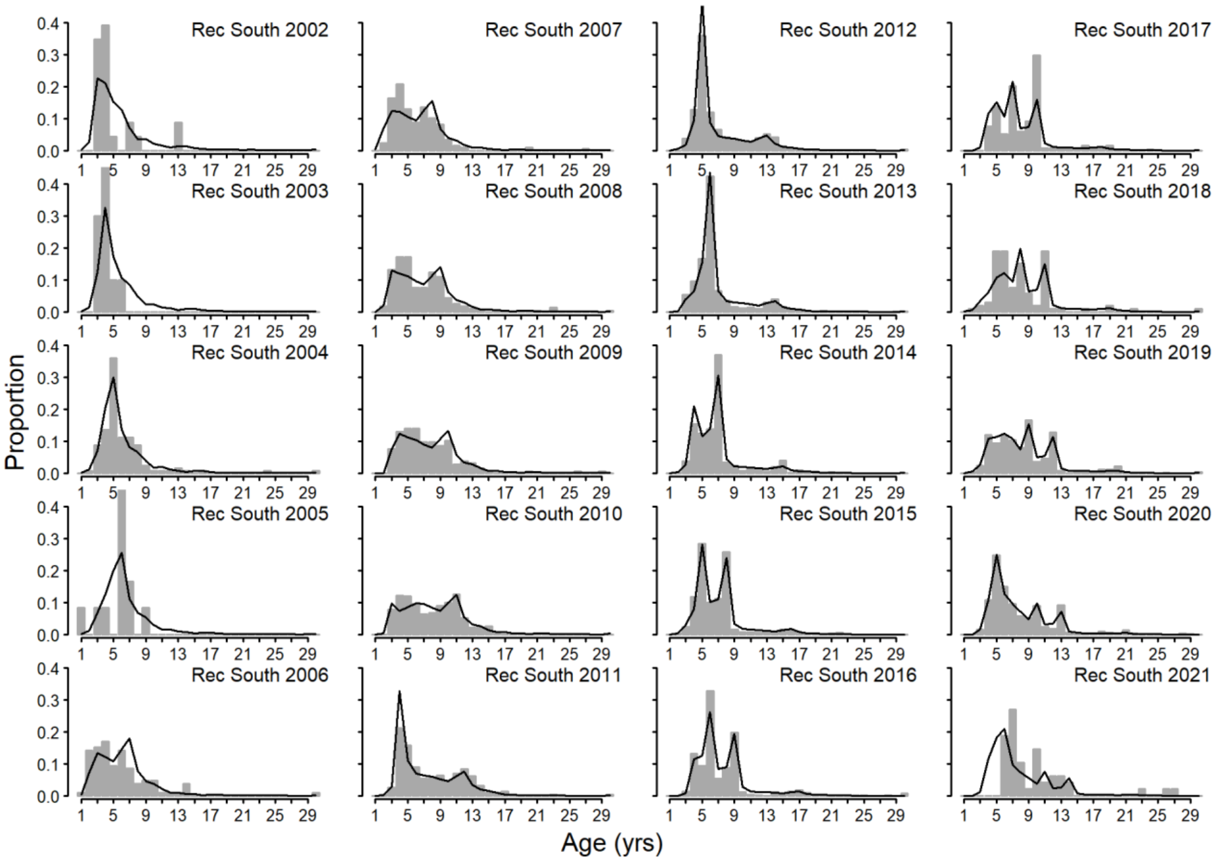


Figure A2.8. Integrated model fits to age composition data collected from recreational catches of Snapper in the southern WCB.

WA Dhufish

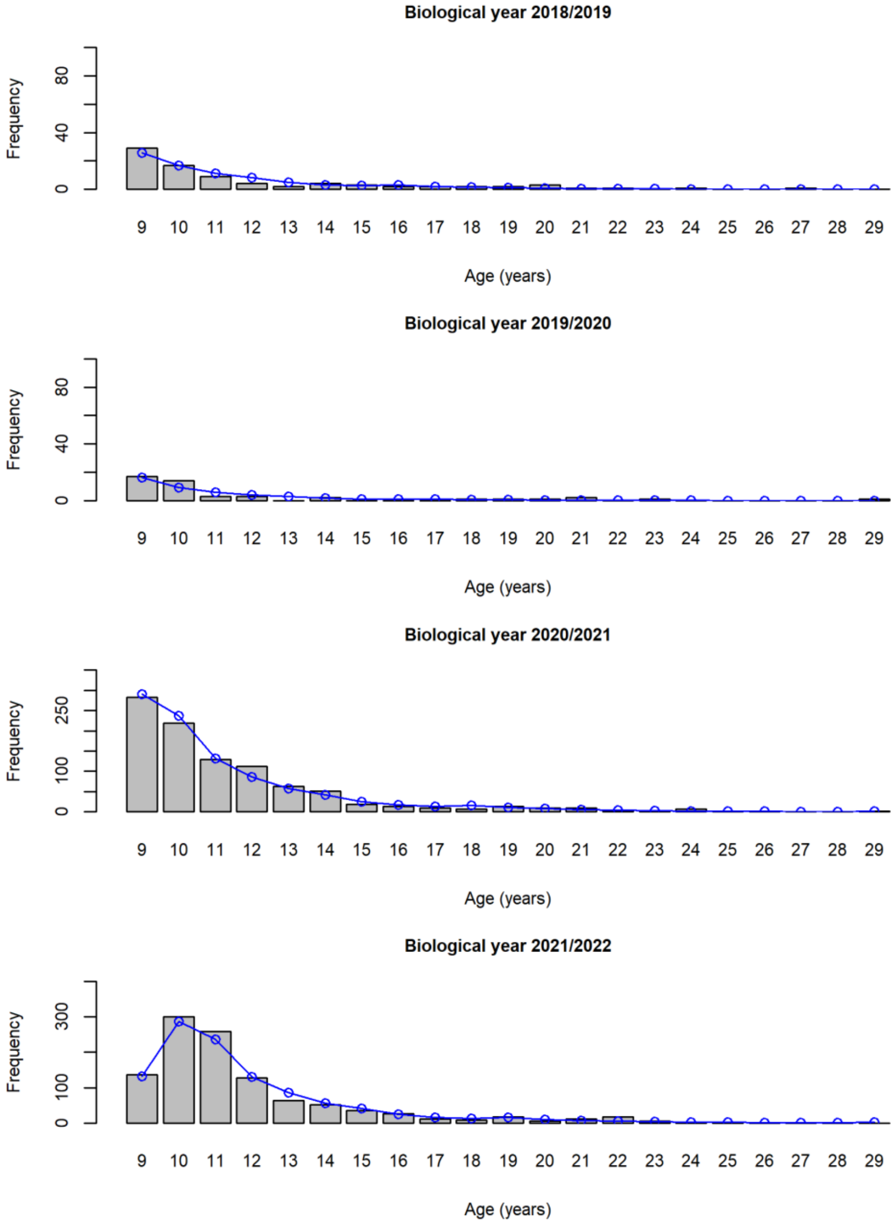


Figure A2.9. Catch curve model fits to age composition data collected from commercial and recreational catches of WA Dhufish in the WCB between 2018-19 and 2021-22.

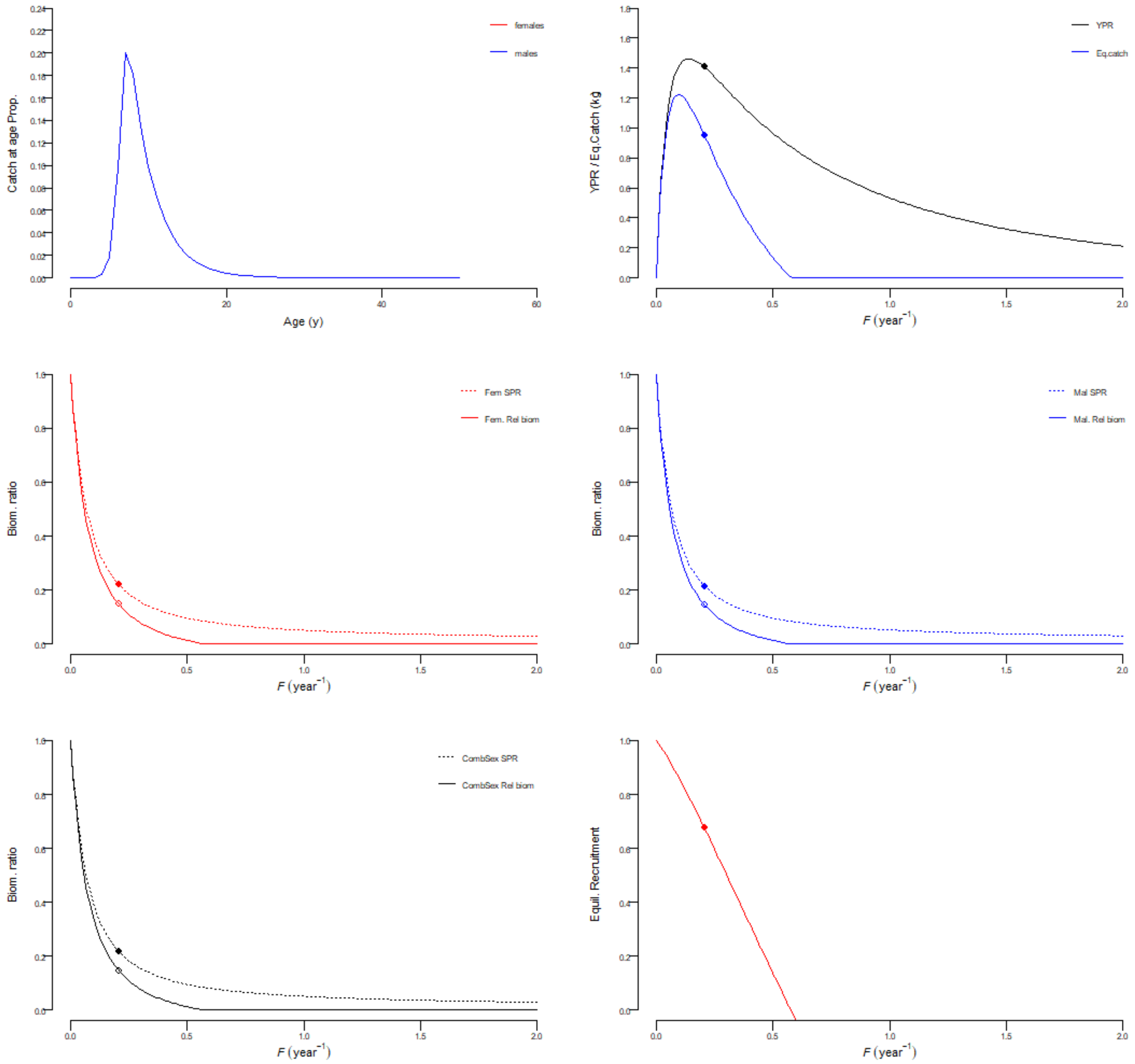


Figure A2.10. Outputs from per-recruit analysis of WA Dhufish in the WCB, including the estimated (top left) catch-at-age and relationships between fishing mortality (*F*; y^{-1}) and (top right) yield-per-recruit/equilibrium catch (kg), spawning potential ratio/relative spawning biomass for (middle left) females, (middle right) males, (bottom left) combined sexes, and (bottom right) equilibrium recruitment. Point estimates correspond to the current estimate of long-term average *F* from catch curve analysis.

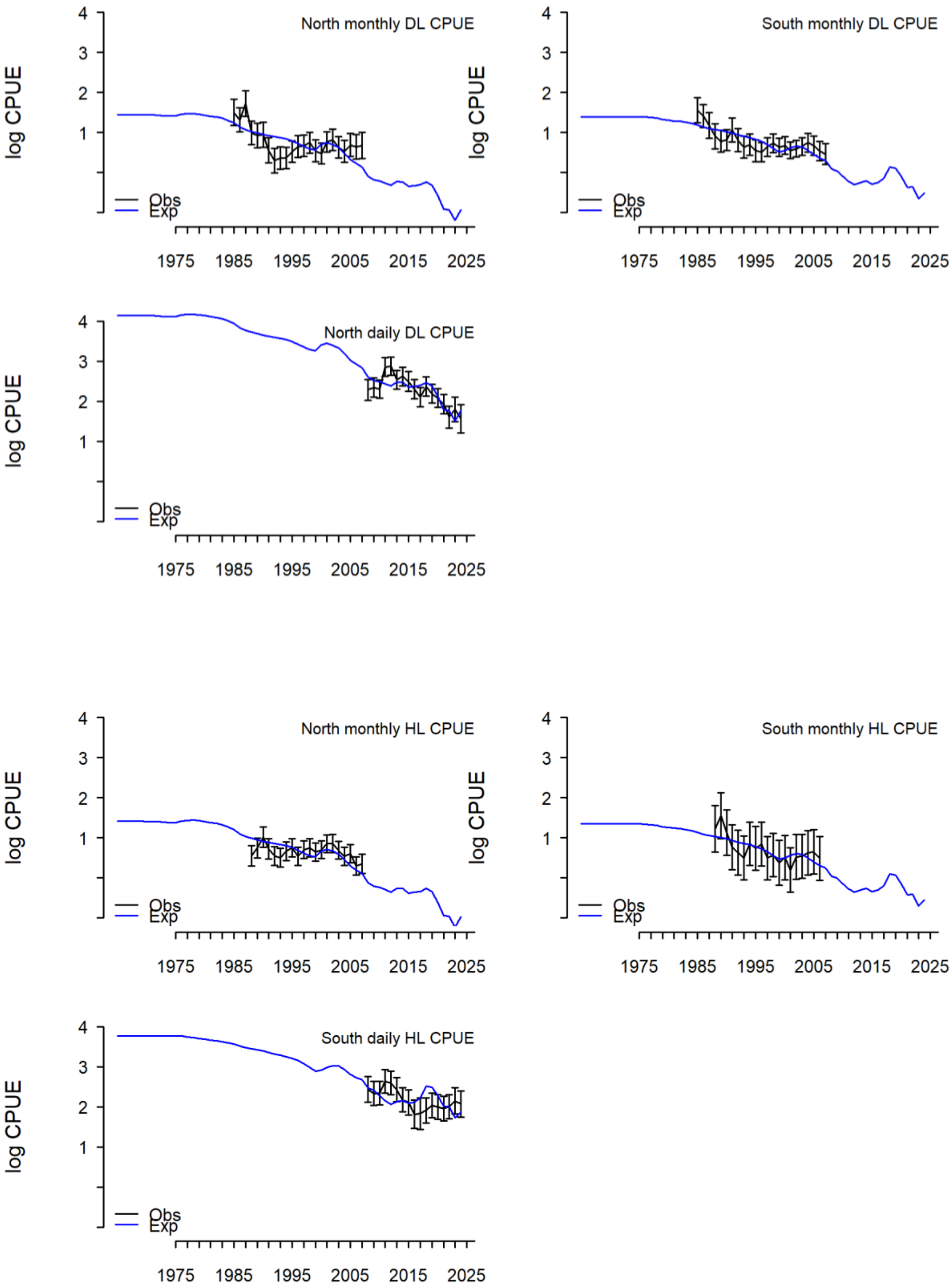
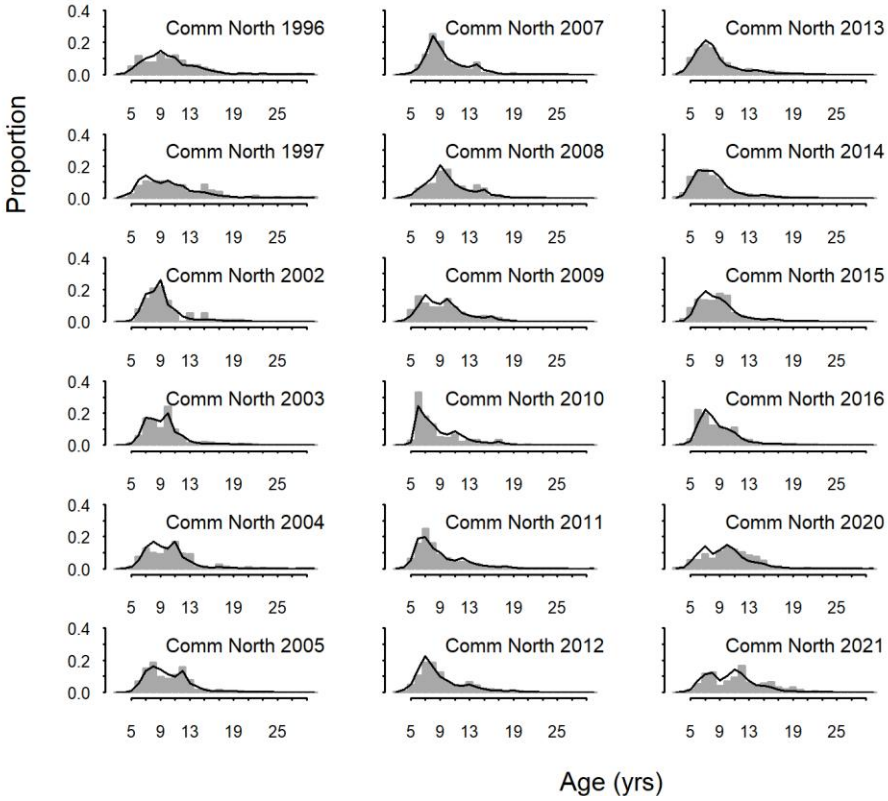


Figure A2.11. Integrated model fits to time series of adjusted standardised CPUE for WA Dhufish in the northern and southern WCB, derived from commercial dropline (DL) and handline (HL) data reported in monthly returns and, since 2008, daily logbooks.

(a) Commercial



(b) Recreational

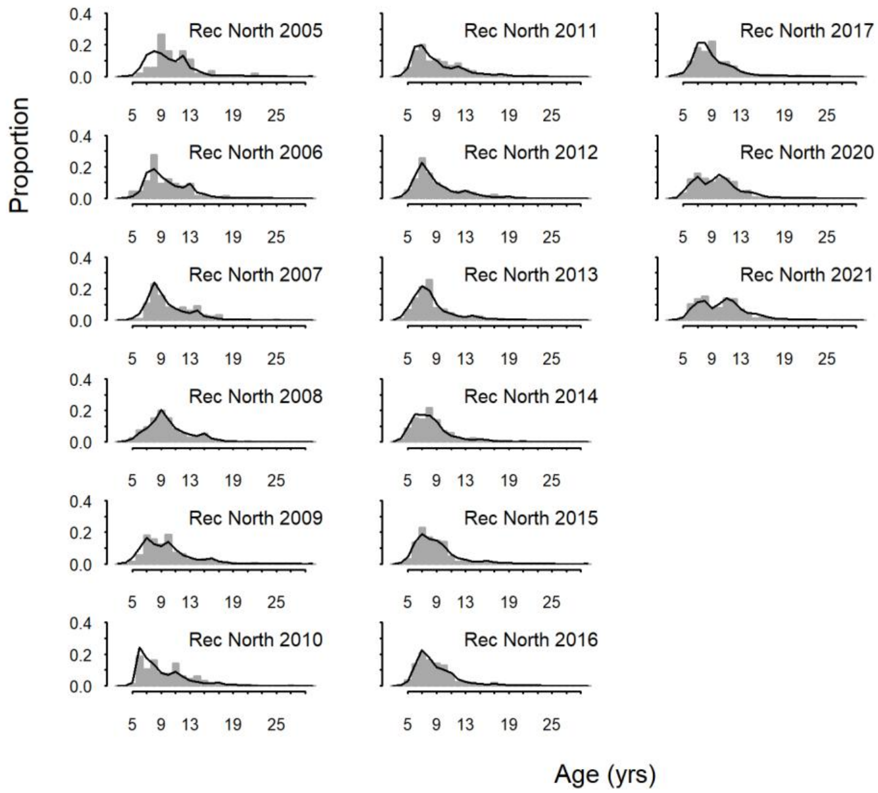


Figure A2.12. Integrated model fits to age composition data collected from (a) commercial and (b) recreational catches of WA Dhufish in the northern WCB.

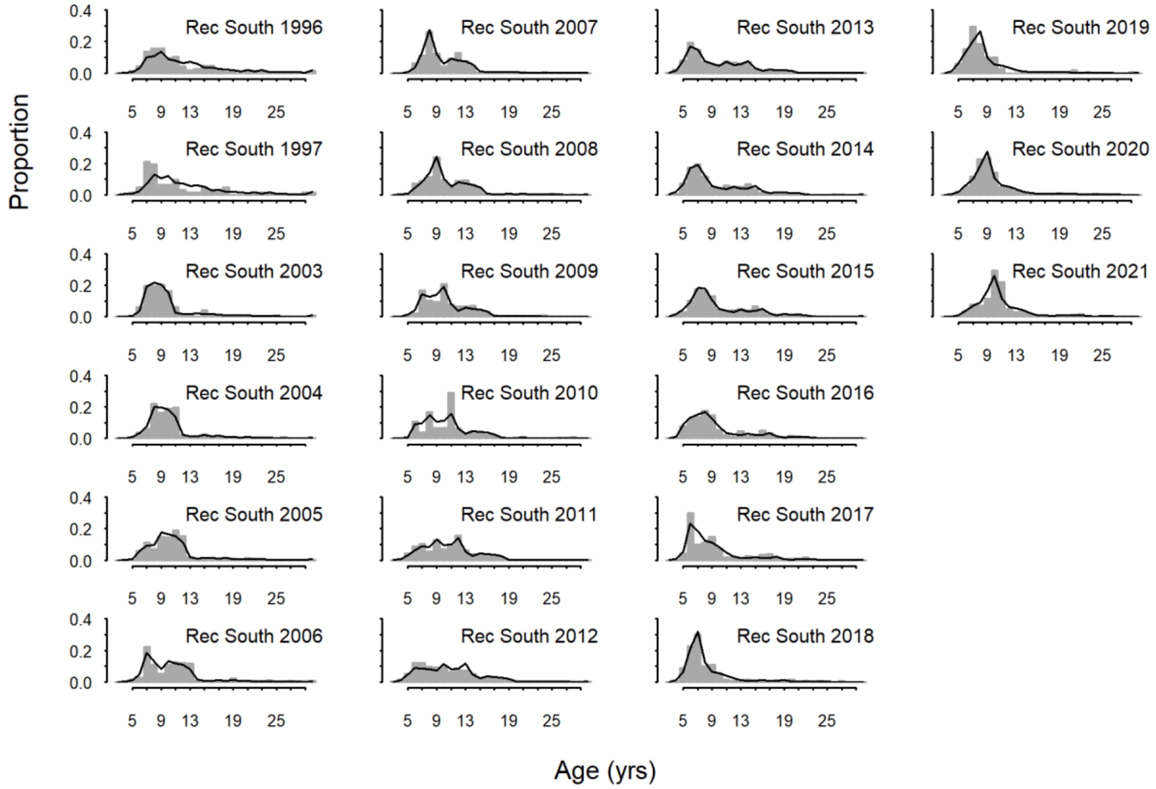


Figure A2.13. Integrated model fits to age composition data collected from recreational catches of WA Dhufish in the southern WCB.

Baldchin Groper

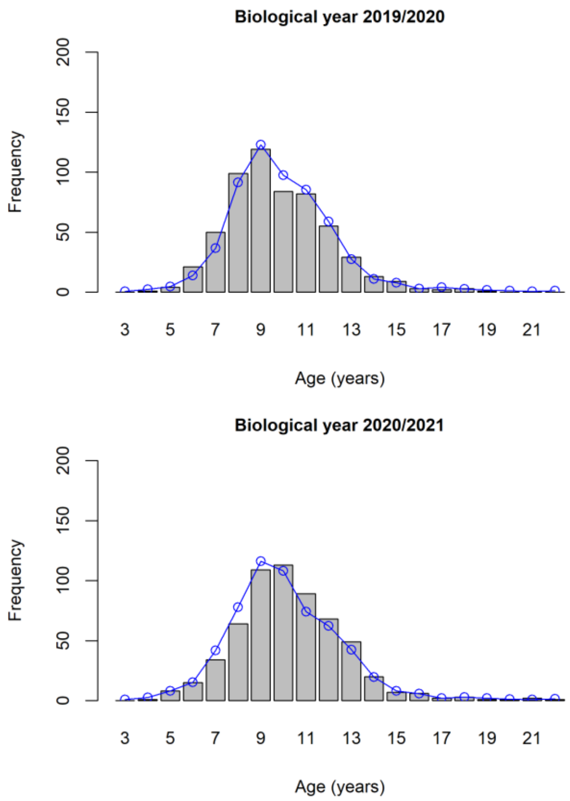


Figure A2.14. Catch curve model fits to age composition data collected from commercial and recreational catches of Baldchin Groper in the Mid-West management area of the WCB in 2019-20 and 2020-21.

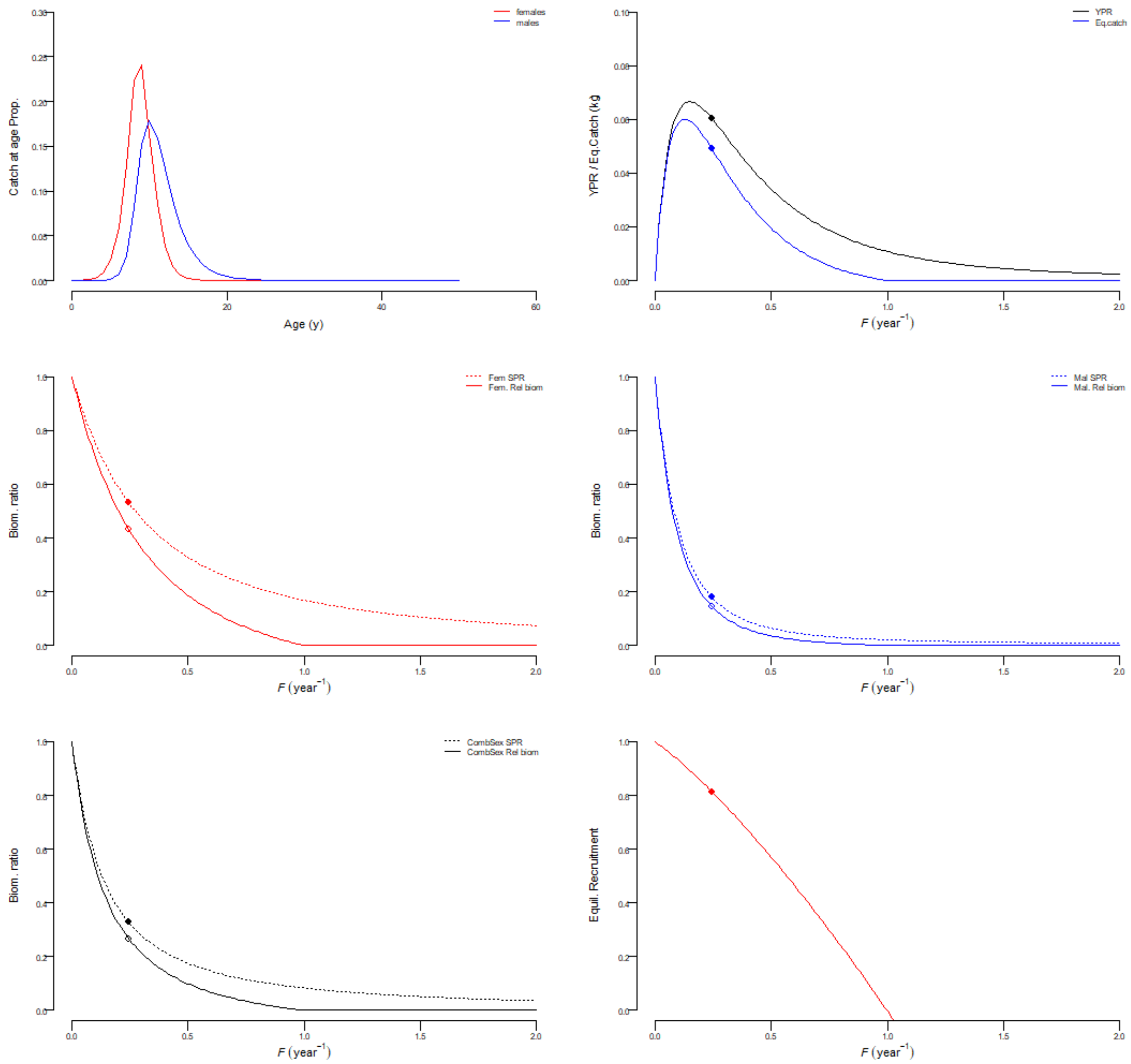


Figure A2.15. Outputs from per-recruit analysis of Baldchin Groper in the Mid-West management area of the WCB, including the estimated (top left) catch-at-age and relationships between fishing mortality (*F*; y^{-1}) and (top right) yield-per-recruit/equilibrium catch (kg), spawning potential ratio/relative spawning biomass for (middle left) females, (middle right) males, (bottom left) combined sexes, and (bottom right) equilibrium recruitment. Point estimates correspond to the current estimate of long-term average *F* from catch curve analysis.

Redthroat Emperor

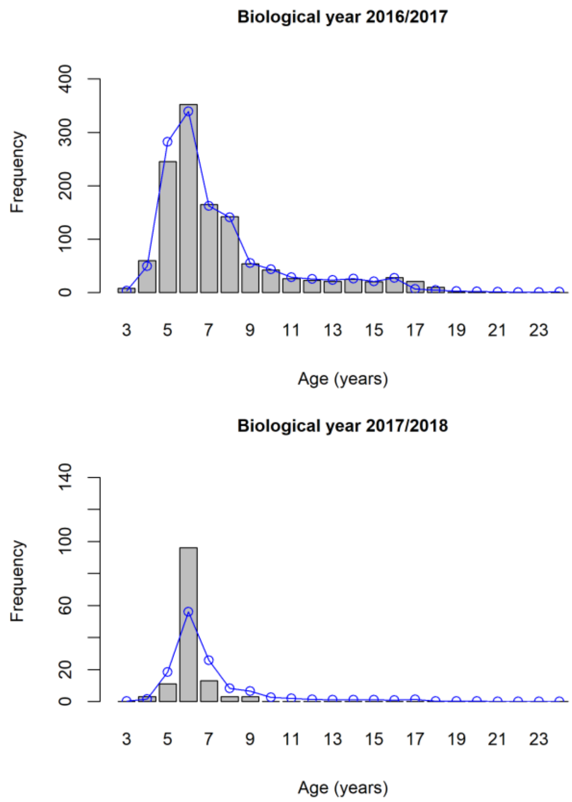


Figure A2.16. Catch curve model fits to age composition data collected from commercial catches of Redthroat Emperor in the northern (Kalbarri and Mid-West) management areas of the WCB in 2016-17.

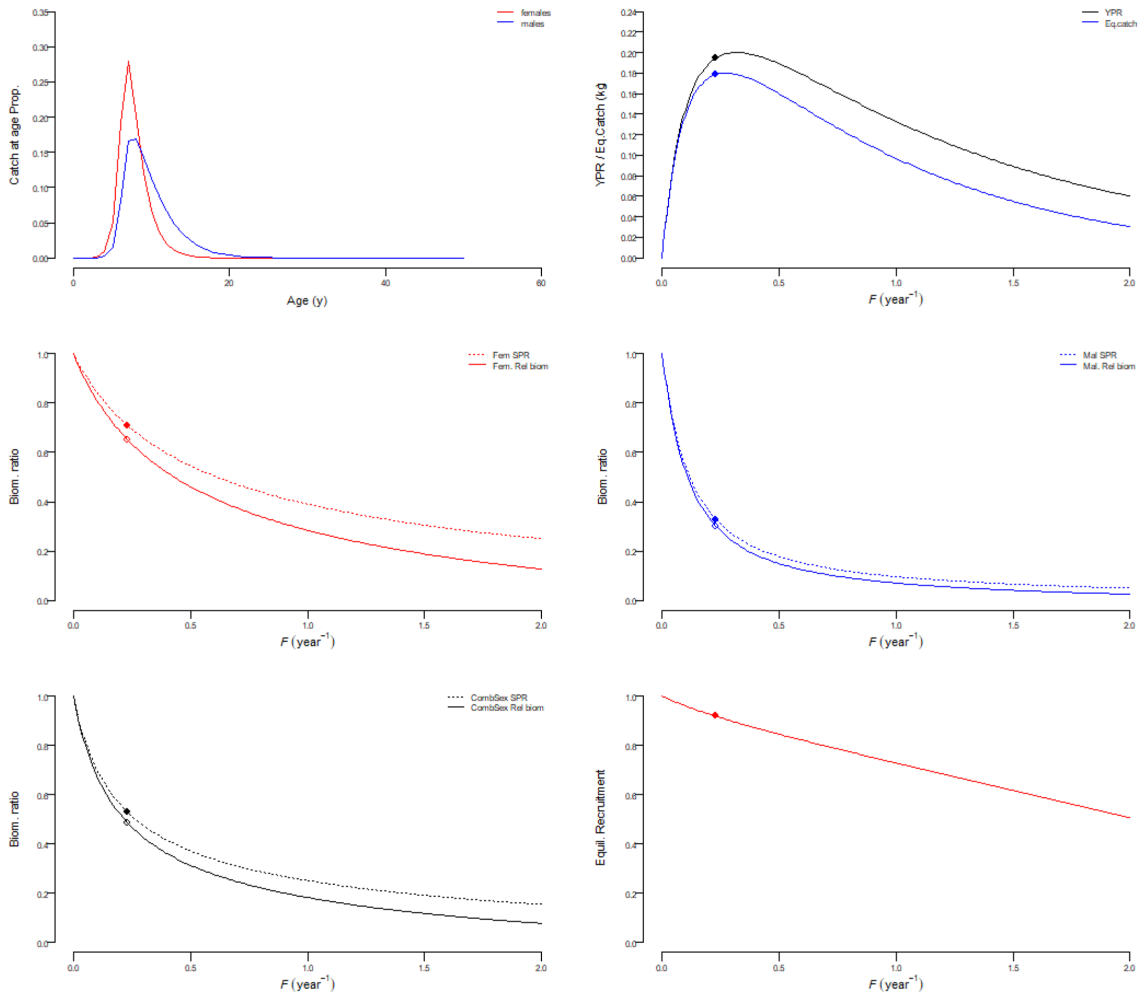


Figure A2.17. Outputs from per-recruit analysis of Redthroat Emperor in the northern (Kalbarri and Mid-West) management areas of the WCB, including the estimated (top left) catch-at-age and relationships between fishing mortality (*F*; y^{-1}) and (top right) yield-per-recruit/equilibrium catch (kg), spawning potential ratio/relative spawning biomass for (middle left) females, (middle right) males, (bottom left) combined sexes, and (bottom right) equilibrium recruitment. Point estimates correspond to the current estimate of long-term average *F* from catch curve analysis.

Bight Redfish

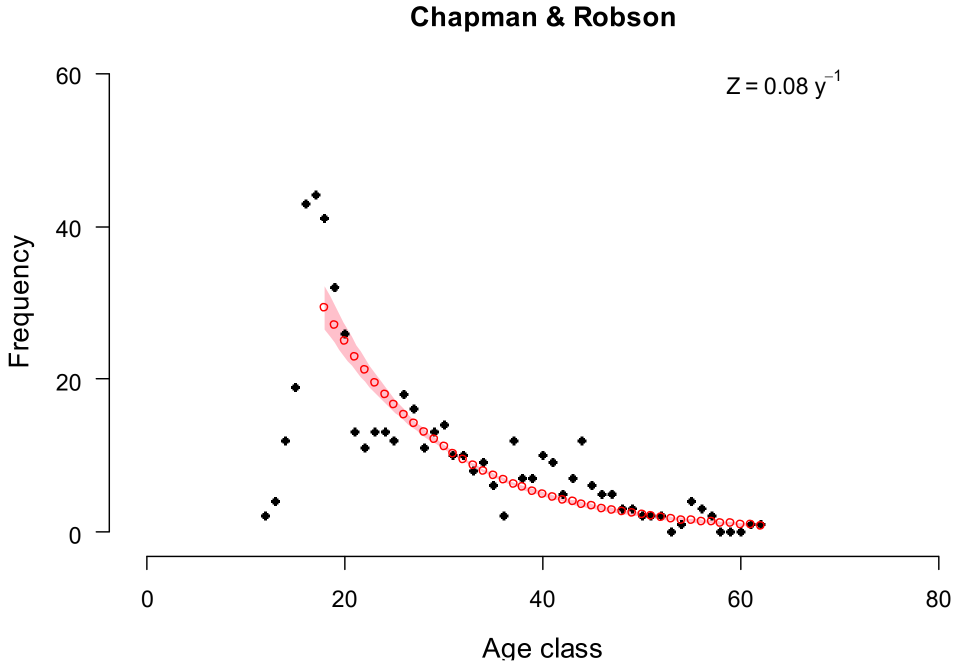


Figure A2.18. Chapman & Robson (1960) catch curve estimate of total mortality (Z; y^{-1}), based on age composition data collected from commercial catches of Bight Redfish in the South-West management area of the WCB in 2019.

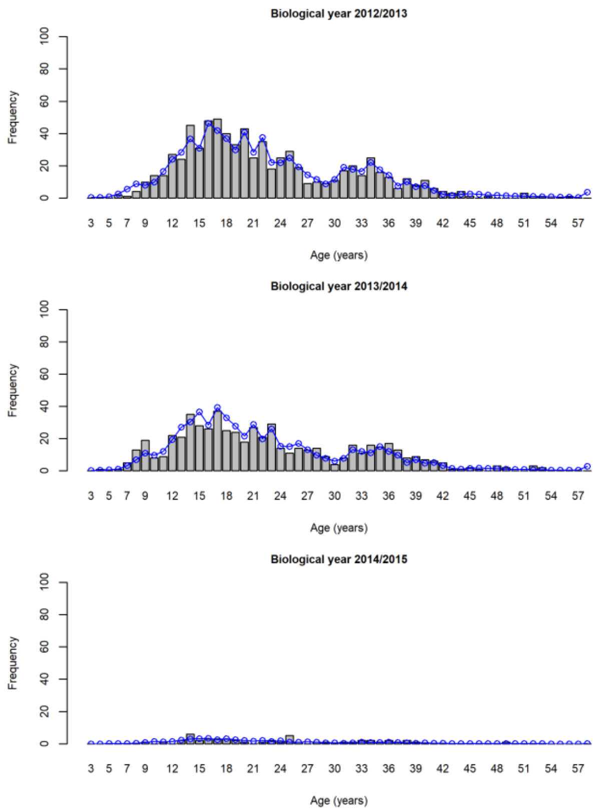


Figure A2.19. Catch curve model fits to age composition data collected from commercial catches of Bight Redfish in the South-West management area of the WCB in 2012-14.

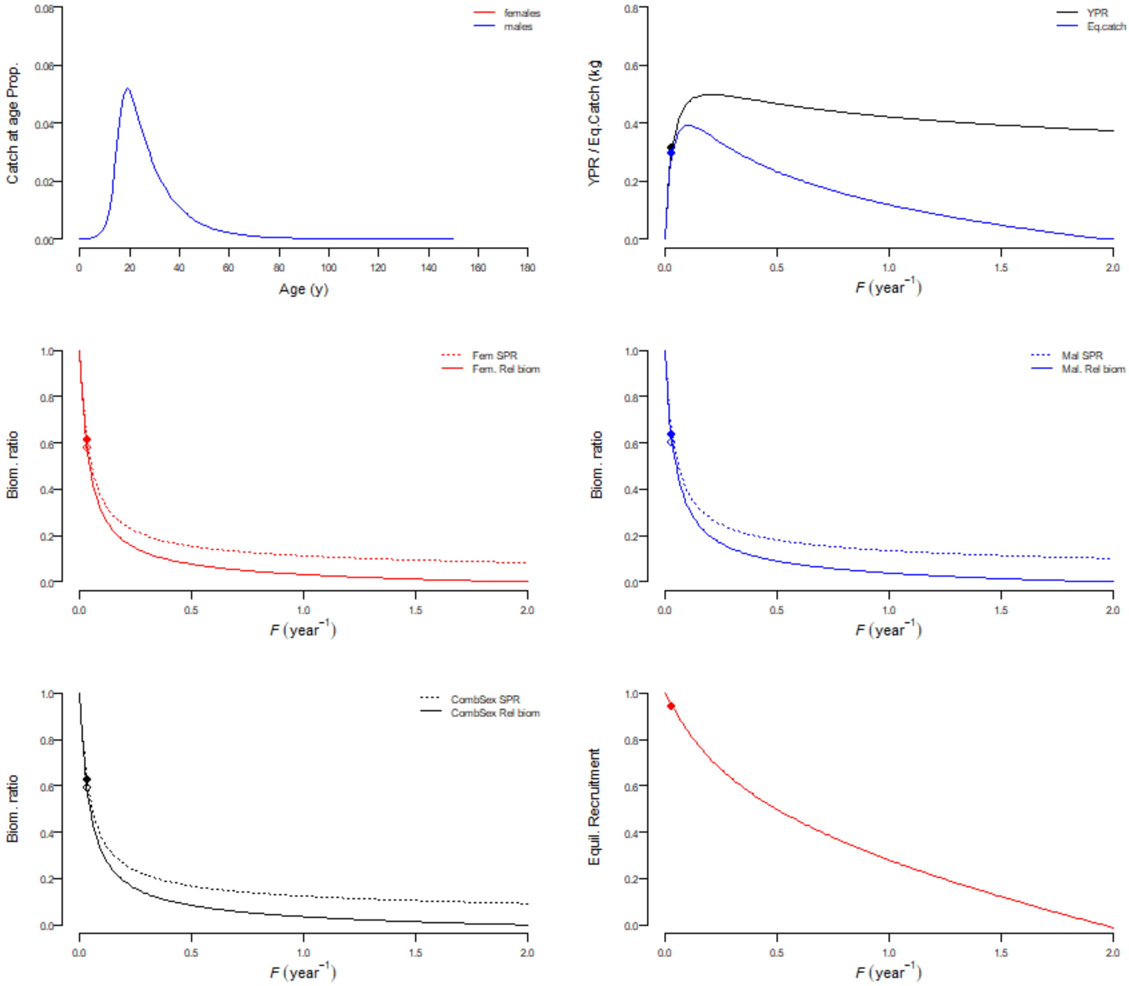


Figure A2.20. Outputs from per-recruit analysis of Bight Redfish in the South-West management area of the WCB, including the estimated (top left) catch-at-age and relationships between fishing mortality (F; y^{-1}) and (top right) yield-per-recruit/equilibrium catch (kg), spawning potential ratio/relative spawning biomass for (middle left) females, (middle right) males, (bottom left) combined sexes, and (bottom right) equilibrium recruitment. Point estimates correspond to the current estimate of long-term average *F* from Chapman & Robson catch curve.

Breaksea Cod

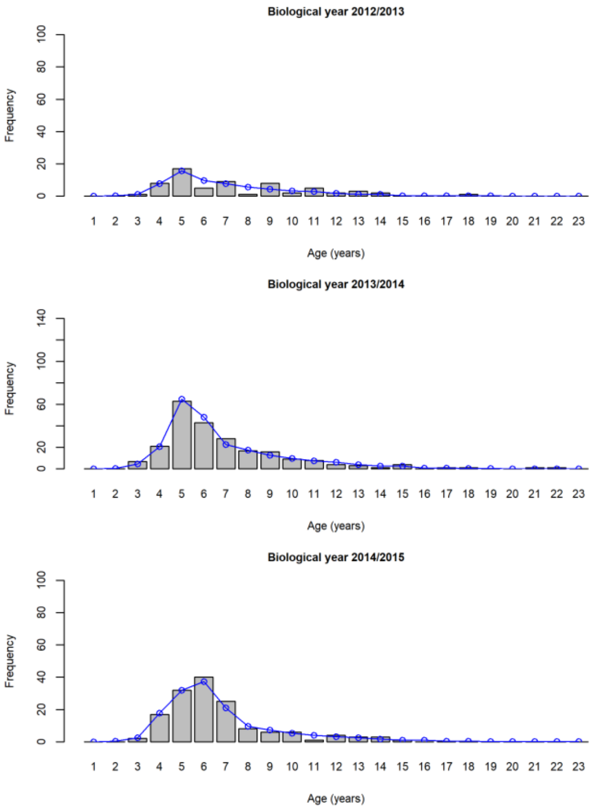


Figure A2.21. Catch curve model fits to age composition data collected from recreational catches of Breaksea Cod in the southern (Metropolitan and South-West) management areas of the WCB in 2013-14.

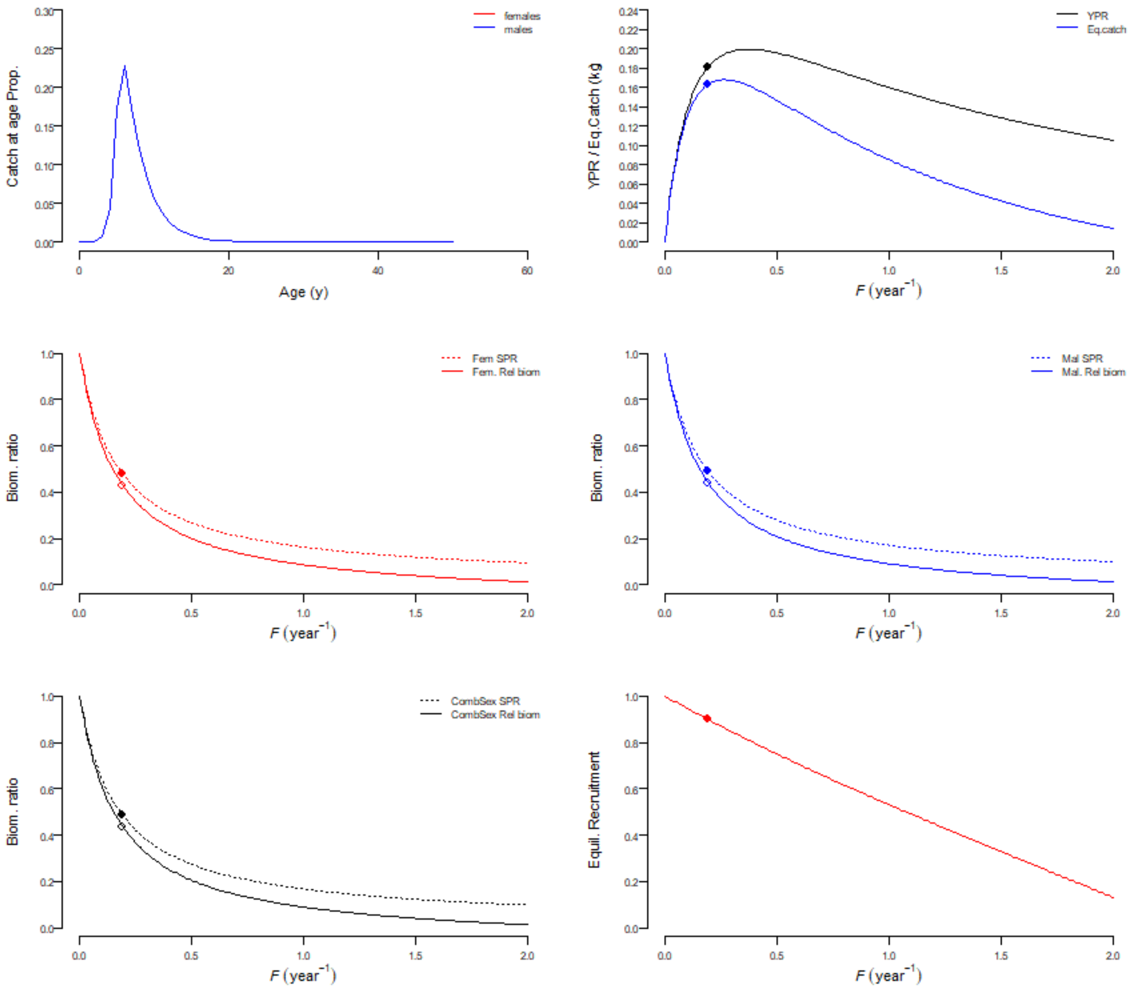


Figure A2.22. Outputs from per-recruit analysis of Breaksea Cod in the southern (Metropolitan and South-West) management areas of the WCB, including the estimated (top left) catch-at-age and relationships between fishing mortality (*F*; y^{-1}) and (top right) yield-per-recruit/equilibrium catch (kg), spawning potential ratio/relative spawning biomass for (middle left) females, (middle right) males, (bottom left) combined sexes, and (bottom right) equilibrium recruitment. Point estimates correspond to the current estimate of long-term average *F* from catch curve analysis.

Appendix 3: Integrated Model Sensitivity Analyses

Different scenarios were undertaken to explore the sensitivity of model outputs to alternative specified values of natural mortality (*M*), steepness of the Beverton-Holt stock-recruitment relationship (*h*), the initial fishing mortality (*F*) at the start of the model period (1960 for Snapper and 1965 for WA Dhufish), and the annual (%) increase in fishing efficiency used to adjust the monthly or daily standardised CPUE.

Snapper – North WCB

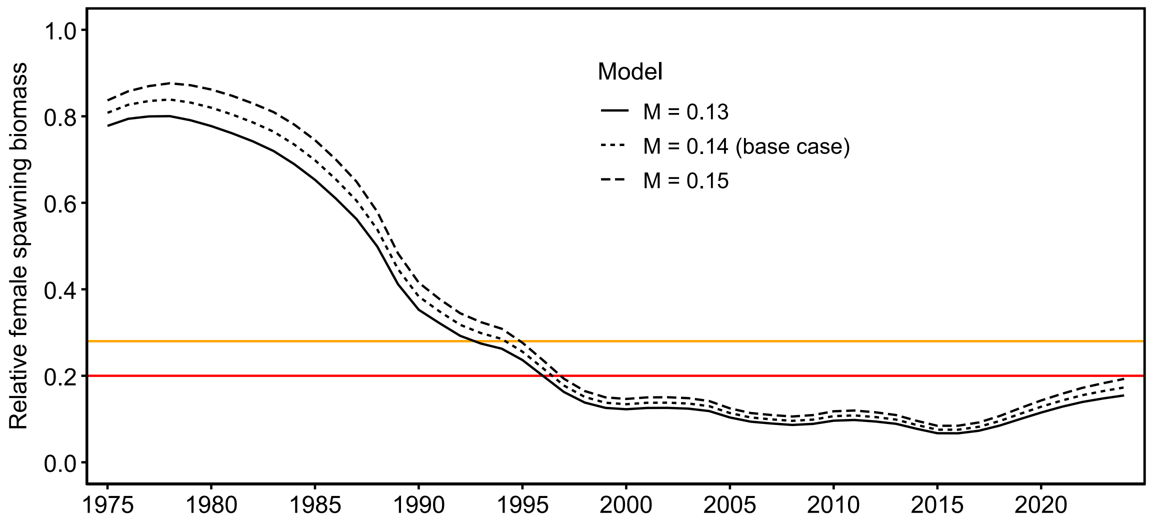


Figure A3.1. Model estimates of annual relative female spawning biomass (B_{rel}) for the Snapper stock in the northern WCB, based on scenarios of alernative specified values of natural mortality (*M*).

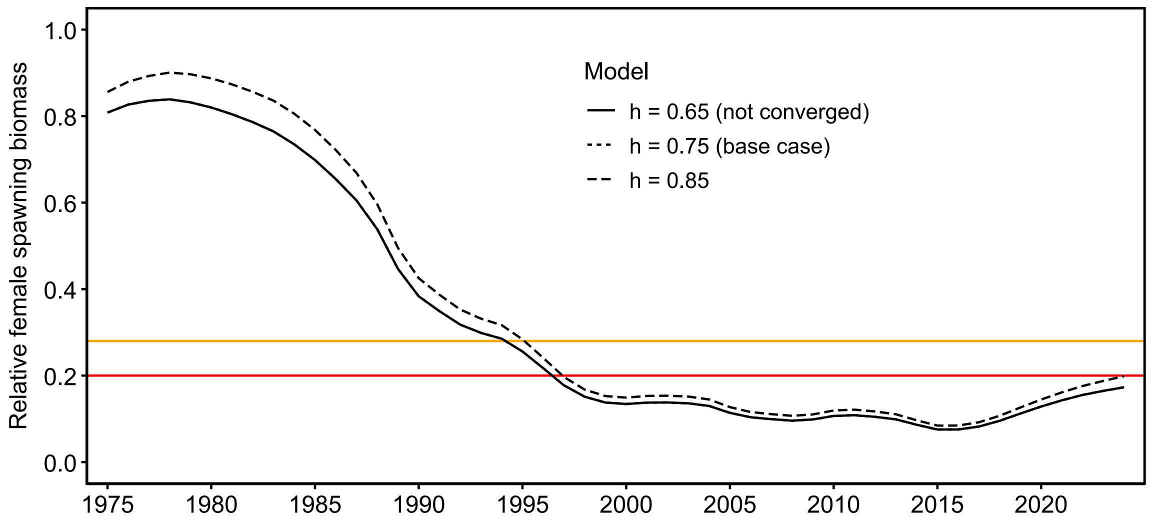


Figure A3.2. Model estimates of annual relative female spawning biomass (B_{rel}) for the Snapper stock in the northern WCB, based on scenarios of alernative specified values of steepness (*h*) of the Beverton-Holt stock-recruitment relationship.

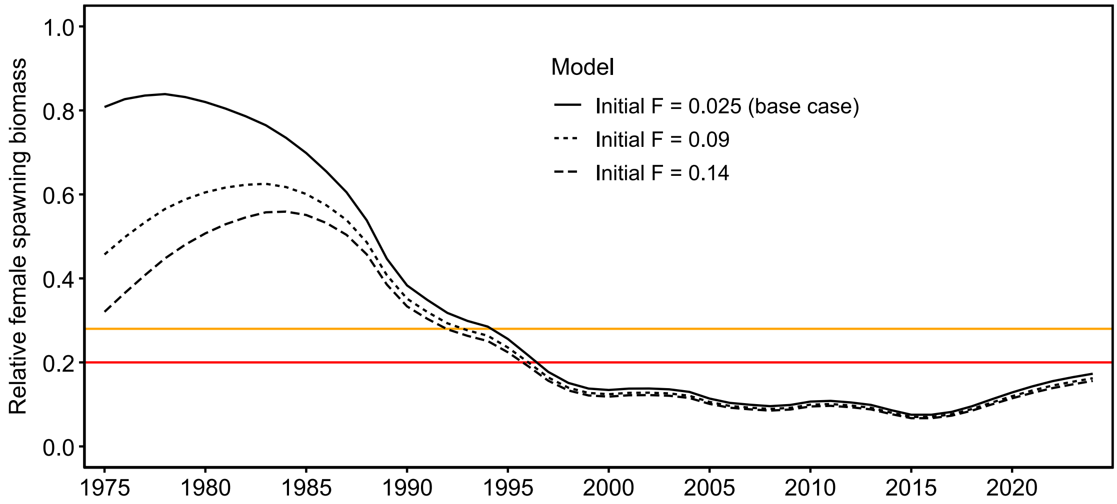


Figure A3.3. Model estimates of annual relative female spawning biomass (B_{rel}) for the Snapper stock in the northern WCB, based on scenarios of alernative specified values of initial fishing mortality (*F*).

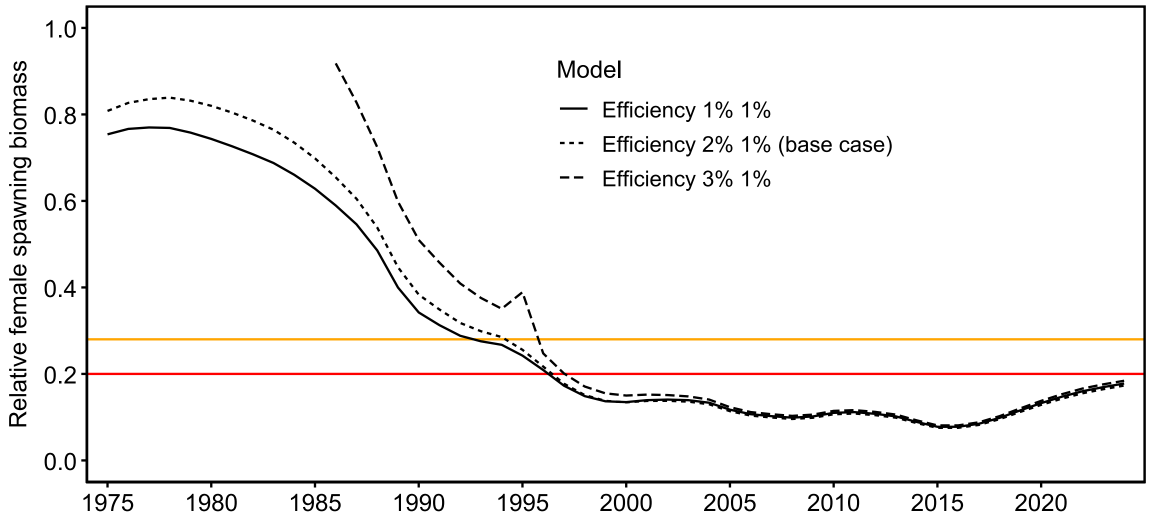


Figure A3.4. Model estimates of annual relative female spawning biomass (B_{rel}) for the Snapper stock in the northern WCB, based on scenarios of alernative specified values of the percent (%) increase in fishing efficiency used to adjust the monthly standardised CPUE time series. Note that the base case 1% efficiency increase used to adjust the daily CPUE time series was kept constant.

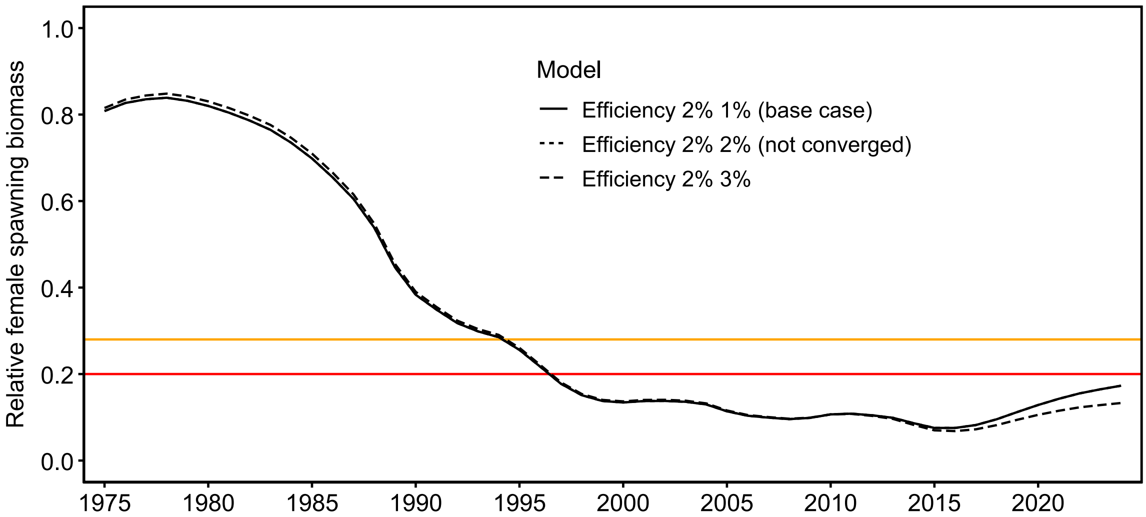


Figure A3.5. Model estimates of annual relative female spawning biomass (B_{rel}) for the Snapper stock in the northern WCB, based on scenarios of alernative specified values of the percent (%) increase in fishing efficiency used to adjust the daily standardised CPUE time series. Note that the base case 2% efficiency increase used to adjust the monthly CPUE time series was kept constant.

Snapper – South WCB

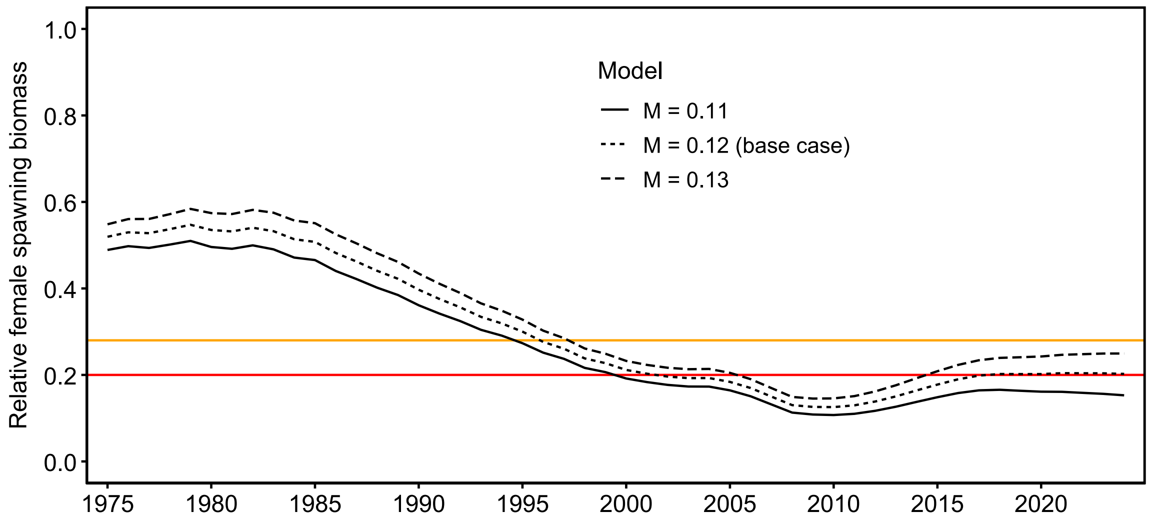


Figure A3.6. Model estimates of annual relative female spawning biomass (B_{rel}) for the Snapper stock in the southern WCB, based on scenarios of alernative specified values of natural mortality (*M*).

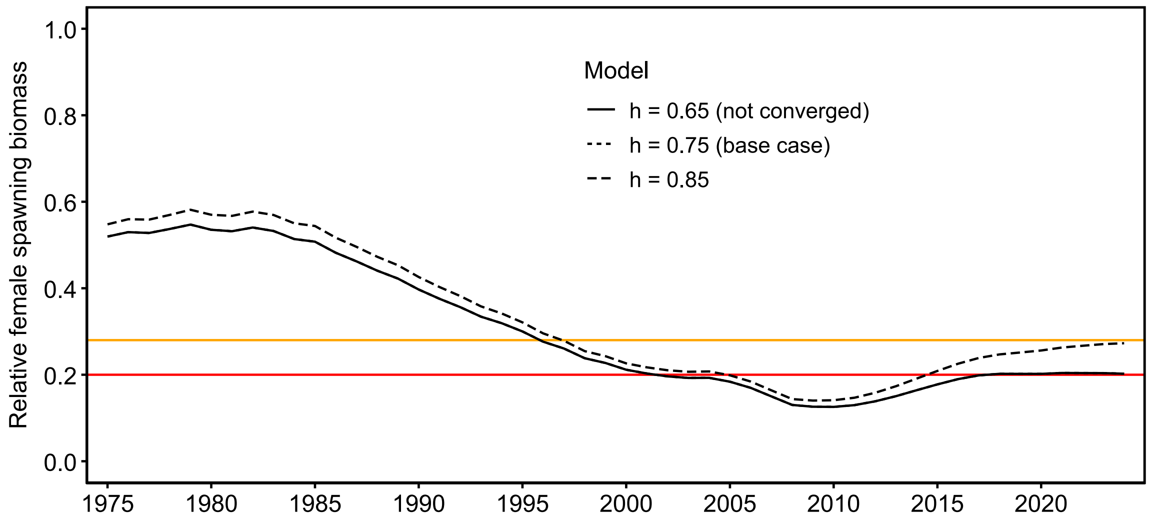


Figure A3.7. Model estimates of annual relative female spawning biomass (B_{rel}) for the Snapper stock in the southern WCB, based on scenarios of alernative specified values of steepness (*h*) of the Beverton-Holt stock-recruitment relationship.

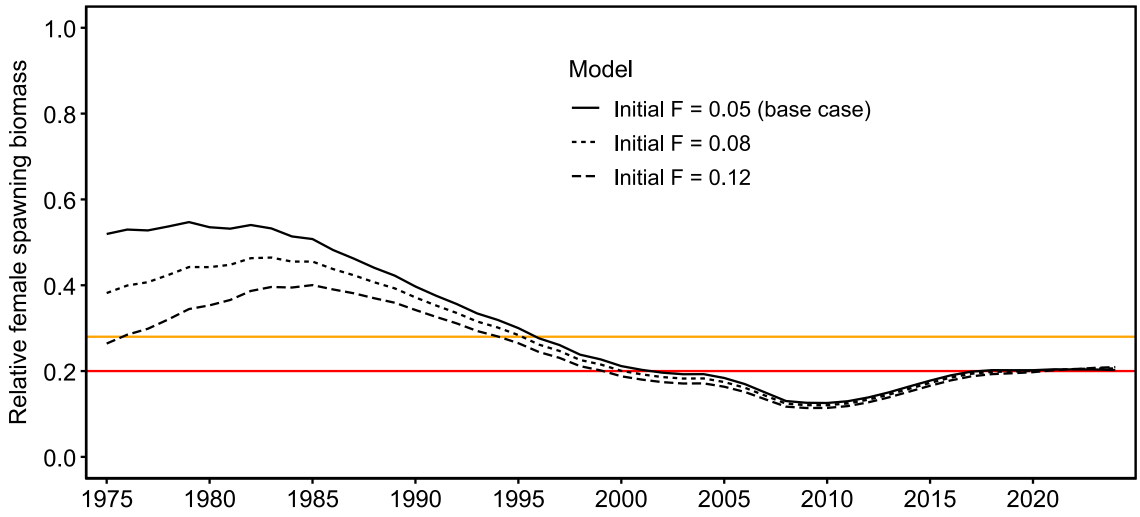


Figure A3.8. Model estimates of annual relative female spawning biomass (B_{rel}) for the Snapper stock in the southern WCB, based on scenarios of alernative specified values of initial fishing mortality (*F*).

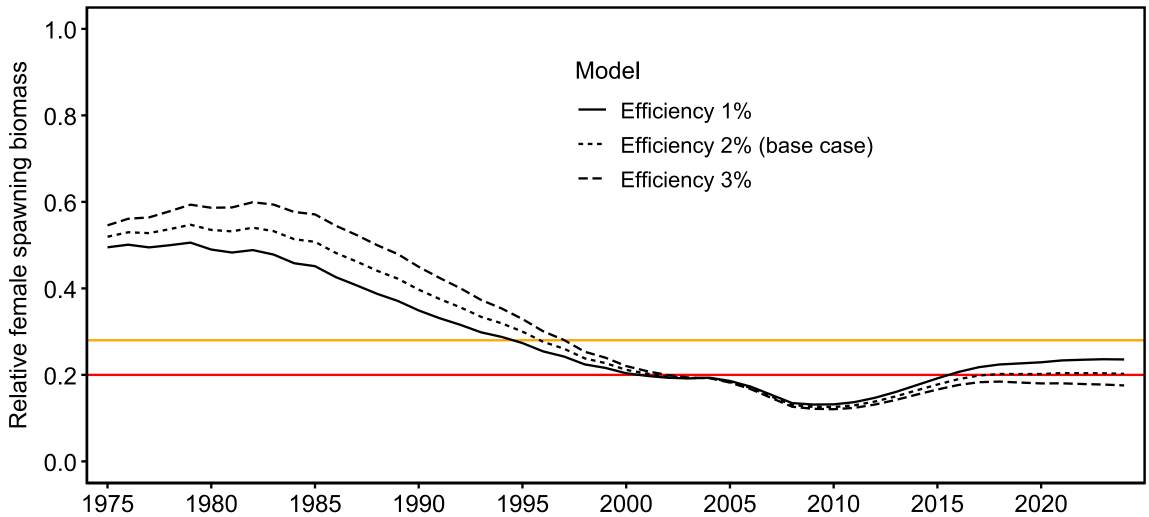


Figure A3.9. Model estimates of annual relative female spawning biomass (B_{rel}) for the Snapper stock in the southern WCB, based on scenarios of alernative specified values of the percent (%) increase in fishing efficiency used to adjust the monthly standardised CPUE time series. Note that there is no time series of CPUE from daily logbook data for Snapper in the southern WCB.

WA Dhufish

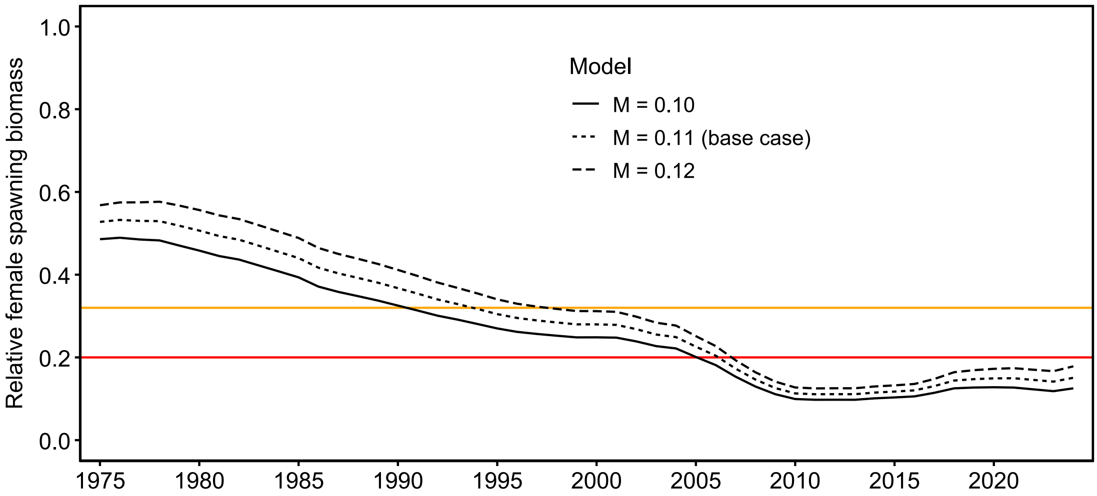


Figure A3.10. Model estimates of annual relative female spawning biomass (B_{rel}) for the WA Dhufish stock in the WCB, based on scenarios of alernative specified values of natural mortality (*M*).

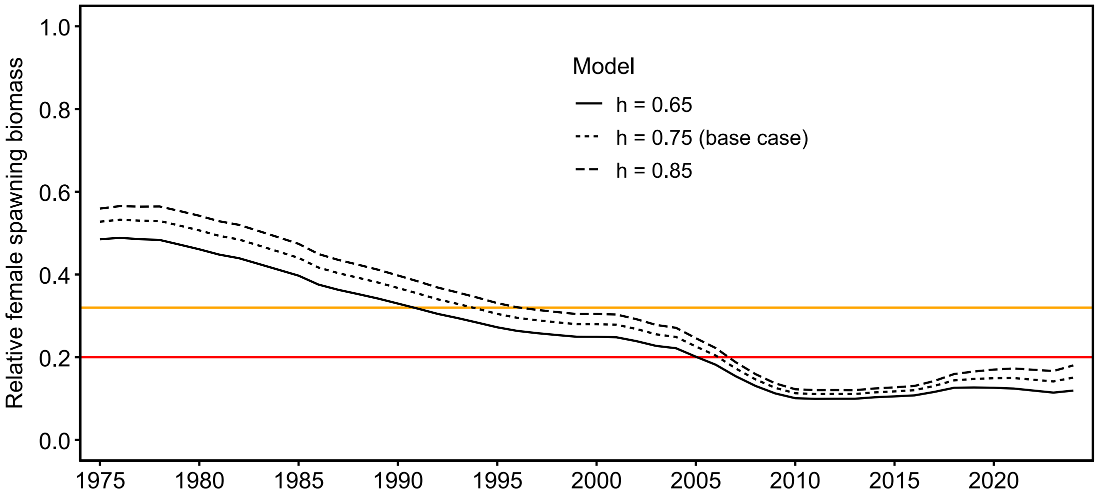


Figure A3.11. Model estimates of annual relative female spawning biomass (B_{rel}) for the WA Dhufish stock in the WCB, based on scenarios of alernative specified values of steepness (*h*) of the Beverton-Holt stock-recruitment relationship.

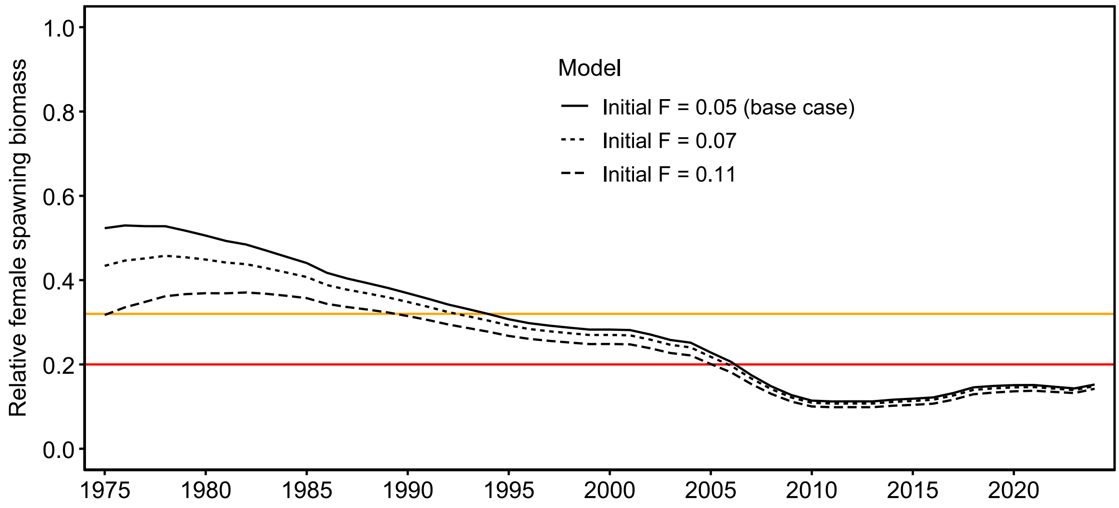


Figure A3.12. Model estimates of annual relative female spawning biomass (B_{rel}) for the WA Dhufish stock in the WCB, based on scenarios of alernative specified values of initial fishing mortality (*F*).

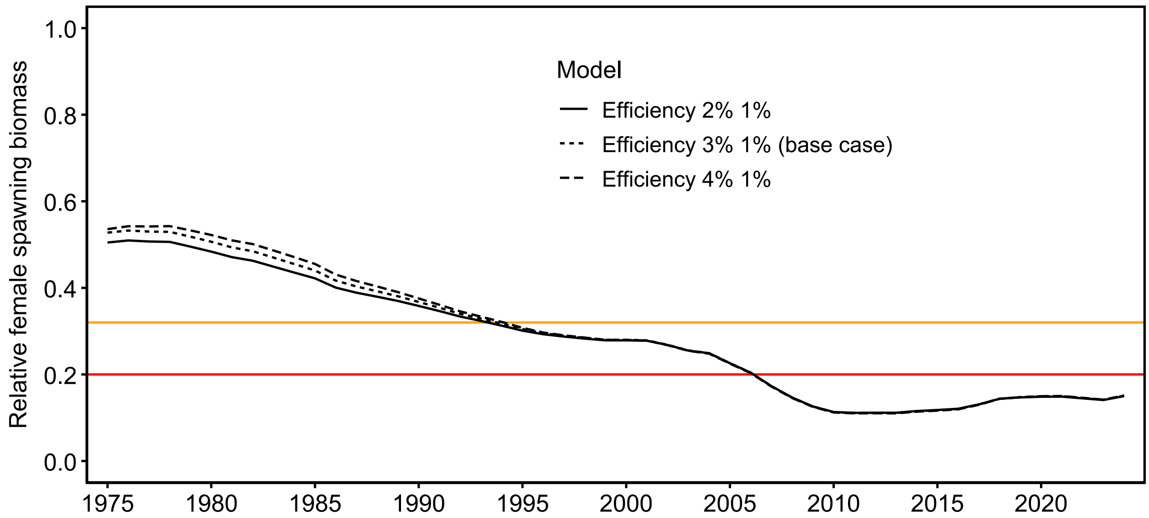


Figure A3.13. Model estimates of annual relative female spawning biomass (B_{rel}) for the WA Dhufish stock in the WCB, based on scenarios of alernative specified values of the percent (%) increase in fishing efficiency used to adjust the monthly standardised CPUE time series. Note that the base case 1% efficiency increase used to adjust the daily CPUE time series was kept constant.

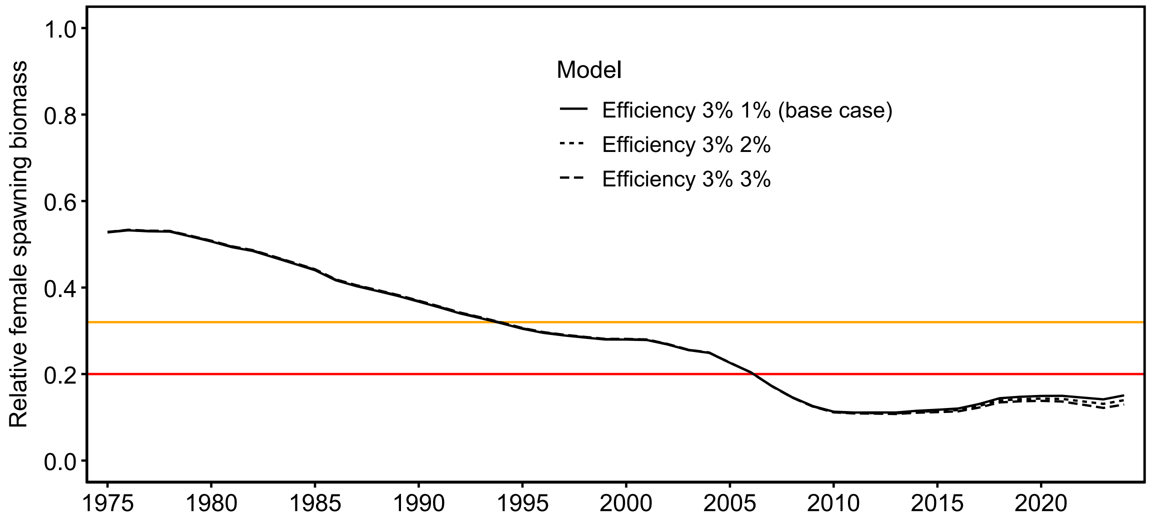


Figure A3.14. Model estimates of annual relative female spawning biomass (B_{rel}) for the WA Dhufish stock in the WCB, based on scenarios of alernative specified values of the percent (%) increase in fishing efficiency used to adjust the daily standardised CPUE time series. Note that the base case 3% efficiency increase used to adjust the monthly CPUE time series was kept constant.