Stock Status Summary – 2021/22

NSW Stock Status Summary – Yellowtail Kingfish (*Seriola lalandi*)

Assessment Authors and Year

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Stock Status

Current stock status	On the basis of the evidence contained within this assessment, Yellowtail Kingfish are currently assessed as **sustainable** for the NSW component of the stock.

Stock structure & distribution

Yellowtail Kingfish (*Seriola lalandi*; Valenciennes 1833) is a highly mobile pelagic species with a widespread distribution extending throughout temperate waters of the Atlantic, Pacific and Indian Oceans (Nugroho et al. 2001). In Australian waters, the species occurs along the entire southern seaboard of the continent from North Island in southern Queensland (10°S) to Trigg Island in Western Australia (32°S) including the east coast of Tasmania, and around Lord Howe and Norfolk Islands (Love & Langenkamp 2003).

Genetic analyses have shown Yellowtail Kingfish in Australia to be divisible into two stocks; the population in Western Australia – the "Western Australia" biological stock – being genetically distinct from Yellowtail Kingfish found in south-eastern Australia (southern Queensland to South Australia (SA), including NSW, Victoria and Tasmania – the "Eastern Australia" biological stock (Miller et al. 2011, Green at al. 2020). Yellowtail Kingfish in New Zealand (NZ) are genetically similar to the "Eastern Australia" stock (Miller at al. 2011). These findings confirm results from previous analyses that found no evidence of genetic differentiation between NZ and NSW Yellowtail Kingfish (Smith et al. 1991). Results of tagging studies show that Yellowtail Kingfish undergo movements spanning southern Queensland, NSW, Victoria, Tasmania and SA, and between eastern Australia, NZ and Lord Howe Island (Gillanders et al. 2001, Holdsworth et al. 2016, Goddard et al. submitted).

Despite this, the data underpinning the analyses presented in this summary were collected from NSW waters only but relate to the assessment of the entire "**Eastern Australia**" biological stock.

Biology

Yellowtail Kingfish is a large-bodied pelagic carnivore (Vergani et al. 2008). The estimated size at which 50% of females and males are mature is 83 cm and 47 cm fork length (FL) respectively corresponding to an age of less than 1 year old for males and 3-4 years for females (Gillanders et al. 1999). Spawning of Yellowtail Kingfish in eastern Australia occurs in spring-summer (Gillanders et al. 1999), with broadcast spawned pelagic eggs and larvae distributed by currents prior to settlement around natural and artificial fish attraction devices (FADS; Dempster & Kingsford 2004). Large schools of juveniles can be found in nearshore coastal waters including estuaries. Solitary or small groups of adults can be found near rocky shores, reefs, islands as well in offshore waters around the continental shelf to depths of more than 300 m (Stewart and Hughes 2008, Goddard et al. submitted). Growth is rapid, being nearly linear between 1 and 11 years old, with fish reaching the 65 cm total length (TL) minimum legal length (MLL) at around 2-3 years of age (Stewart et al. 2004). Yellowtail Kingfish can attain ~190 cm TL and can weigh up to ~70 kg with a maximum recorded age of 21 years (Stewart et al. 2004).

FISHERY STATISTICS

Catch information

Commercial

Prior to the 1980s, the commercial catch of Yellowtail Kingfish in NSW was approximately 200 t per year taken primarily using line fishing methods. In the early 1980s, pelagic fish traps ('kingfish' traps) were developed and resulted in landings increasing to an average of approximately 550 t per year in the period 1983-84 to 1989-90 (Fig. 1). The catch declined dramatically through the 1990s and pelagic fish traps were banned in 1996. Since then, the catch has fluctuated considerably around an average of approximately 150 t per year (range ~250 - <100 t). In recent history, a decline in landings has been recorded from 264 t in 2009-10 to 67 t in 2021-22. The entire catch is reported by the Ocean Trap and Line Fishery (OTLF).

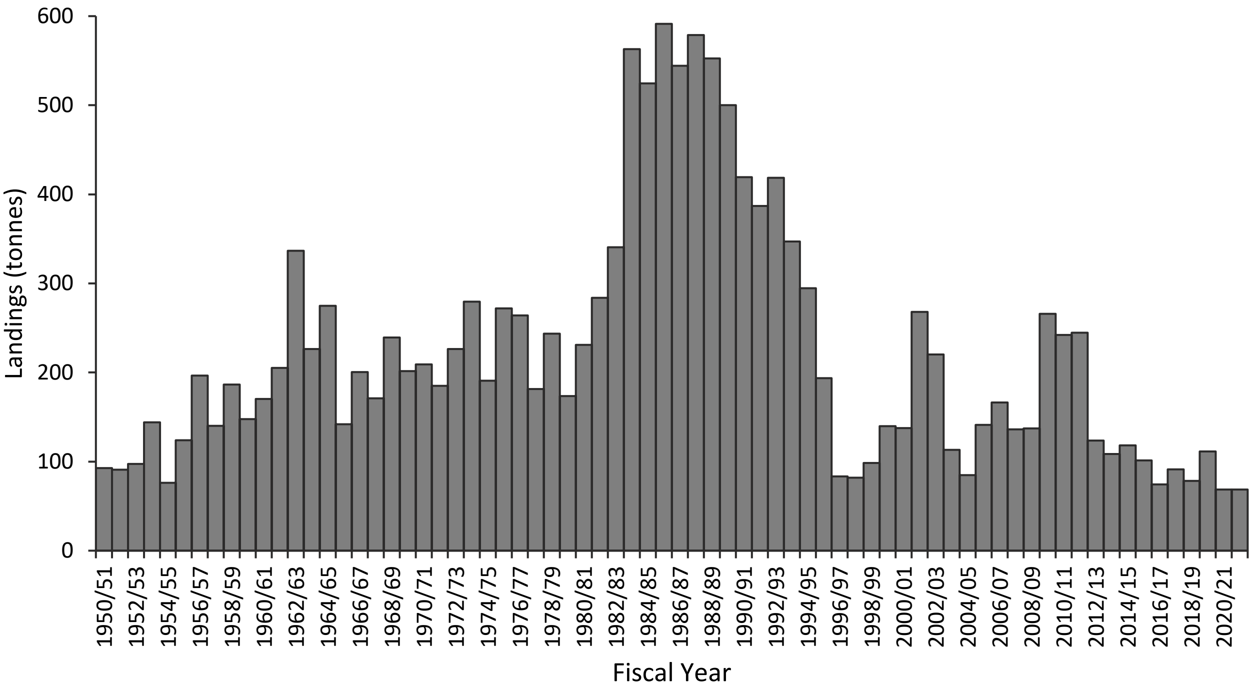

Figure 1. Commercial landings (including available historical records) of Yellowtail Kingfish for NSW from fiscal years 1950-51 to 2021-22 for all commercial fishing methods.

Recreational & Charter Fishery

The most recent estimate of the recreational harvest of Yellowtail Kingfish in NSW was approximately 31,000 fish weighing an estimated 114 t during 2019-20 (Fig. 2; Murphy et al. 2022). In 2017-18, approximately 45,000 fish weighing an estimated 129 t were estimated harvested (Fig. 2; Murphy et al. 2020). These estimates only encompassed harvest from NSW households within which a long-term (1-3 year) Recreational Fishing Fee licence holder resided (RFL household). Re-analysis of a previous survey done during 2013-14 (West et al. 2015) for all NSW residents, to allow a comparison with the two most recent surveys, produced an estimate of approximately 41,000 Yellowtail Kingfish weighing an estimated 120 t harvested by RFL households (Murphy et al. 2020). In 2000-01 the National Recreational and Indigenous Fishing Survey (Henry & Lyle 2003) estimated a recreational harvest by all fishers in NSW waters (including interstate visitors) at approximately 59,000 fish weighing an estimated 219 t. While these survey results are not directly comparable due to different sampling frames, they likely represent a slight decline in recreational harvest through time and consistently indicate that the recreational harvest is likely larger than the commercial catch since 2000-01 (Fig. 1). Harvest from the NSW Charter Fishery is included within the recreational survey estimates.

Indigenous

Aboriginal cultural catch of Yellowtail Kingfish has not been quantified in NSW.

Illegal, Unregulated and Unreported

The level of Illegal, Unregulated and Unreported (IUU) fishing has not been quantified.

Total Harvest Estimates

Total historical harvest of Yellowtail Kingfish in NSW was reconstructed by estimating recreational harvest prior to, and between, recreational survey estimates (Fig. 2). Hindcasting the recreational harvest prior to 2000-01 was done using estimates of national recreational marine fishing effort reported in Kleisner et al. (2015), which used coastal population statistics from the Australian Bureau of Statistics (ABS) with linear interpolation between census years. Estimates of recreational harvest were made by applying the relative recreational fishing effort each year relative to 2000 by the estimated harvest in 2000-01. This estimate was made using the numbers as reported in the Henry & Lyle (2003) and NSW DPI unpublished estimates of the proportion of Yellowtail Kingfish within the survey species group (which included Amberjack and Samsonfish) as being 79% in ocean waters and 100% in estuary waters, with average weights being 2.9 and 2.8 kg respectively. After 2000-01, harvest was assumed to follow a linear path between each survey, with the estimate for 2020-21 and 2021-22 being set as the same as in 2019-20.

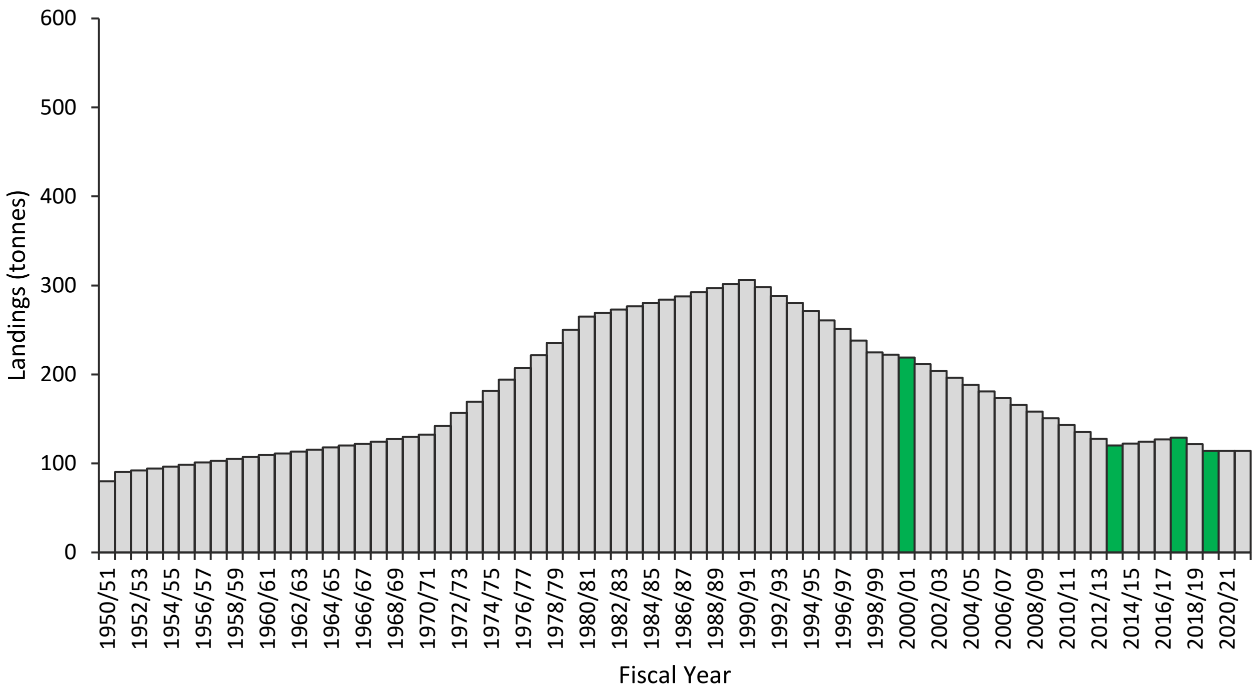

Figure 2. Recreational catch reconstruction for Yellowtail Kingfish in NSW using an estimated recreational catch of 219 t for 2000-01. The green bars represent recreational survey estimates for 2000-01, 2013-14, 2017-18 and 2019-20.

The recreational harvest of Yellowtail Kingfish was estimated to have increased rapidly during the 1970s and 1980s, peaking in 1990-91 (Fig. 2). There was a decline in recreational harvest between the surveys in 2000-01 and 2013-14 (noting that the MLL was increased from 60 to 65 cm total length in 2007), and a slight increase between 2013-14 and 2017-18. There was a slight decrease in recreational harvest between the surveys in 2017-18 and 2019-20.

Combining the NSW commercial and recreational harvest estimates indicate that the fishery increased during the 1970s and early 1980s, peaking during the mid-1980s (Fig. 3). Total harvest since the mid-1990s has been considerably lower with harvest over recent years being among the lowest estimated for the species.

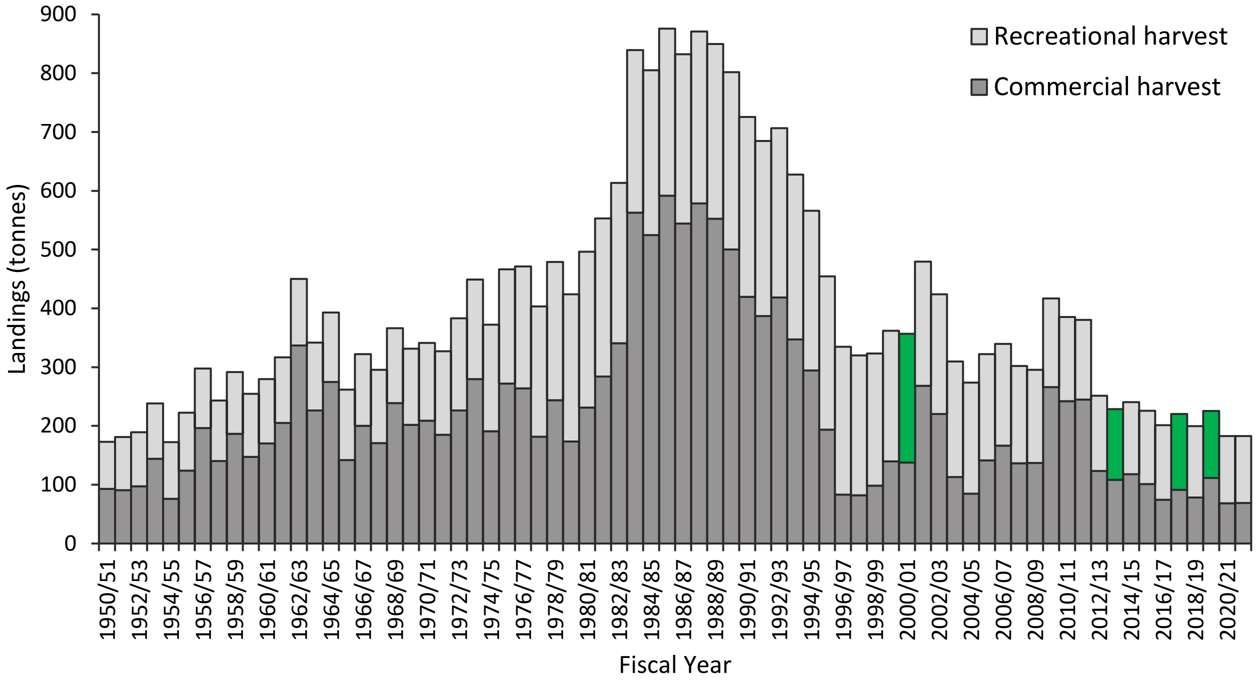

Figure 3. Reconstructed total catch history for Yellowtail Kingfish in NSW 1950-51 to 2021-22.

Fishing effort information

Effort line-fishing (all methods) in the OTLF have declined from ~4,200 days in 2009-10 and 2011-12 to a historic low of 2,109 days in 2021-22 (Fig. 4).

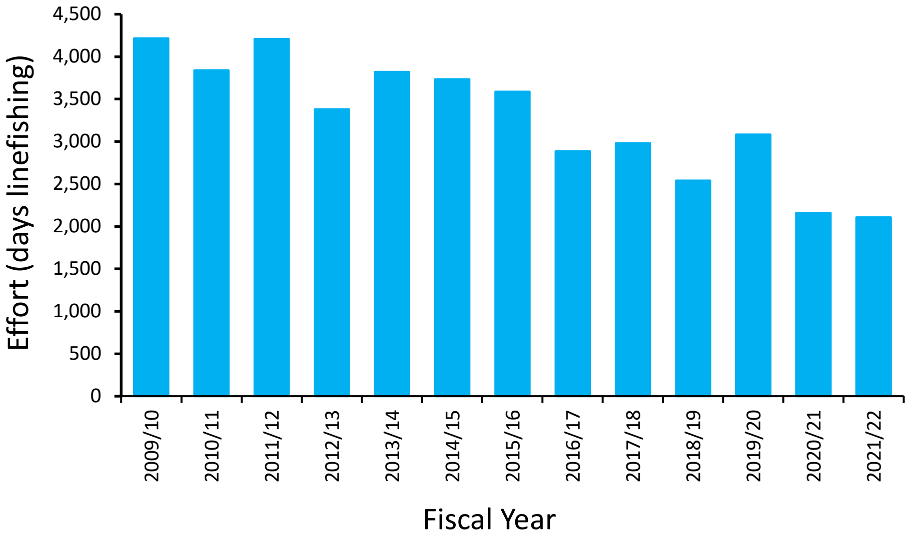

Figure 4. Annual reported days fished for Yellowtail Kingfish (all commercial linefishing methods) 2009-10 to 2021-22.

Catch rate trends

Standardised Commercial CPUE

Standardised catch per unit effort (kg.day^{-1}) for the four main commercial (OTL) linefishing methods used to land Yellowtail Kingfish – handlining, jigging, trolling and droplining – was estimated using a general linear model (LM) constructed using the 'cede' package (Haddon et al. 2018) in 'R' statistical software. CPUE was standardised for variations across months, areas and fishers to a mean estimate of CPUE by year for the periods 1997-98 – 2021-22 and 2009-10 – 2021-22, in order to examine CPUE trends before and after a reporting change (from monthly to daily catch reporting) introduced in 2009. These four methods comprised ~95% of the landed commercial catch of Yellowtail Kingfish during the reporting period.

1997-98 – 2020-21 (monthly reporting)

Handlining has accounted for the majority (~48%) of total reported commercial Yellowtail Kingfish catch since 1997-98. The resulting monthly-based standardised CPUE for handlining shows an increase from its lowest value in the reporting period in 1997-98 to a peak in 2010-11 followed by a decline to its 2021-22 value (Fig. 5). Overall, there was a ~115% increase between 1997-98 and 2021-22.

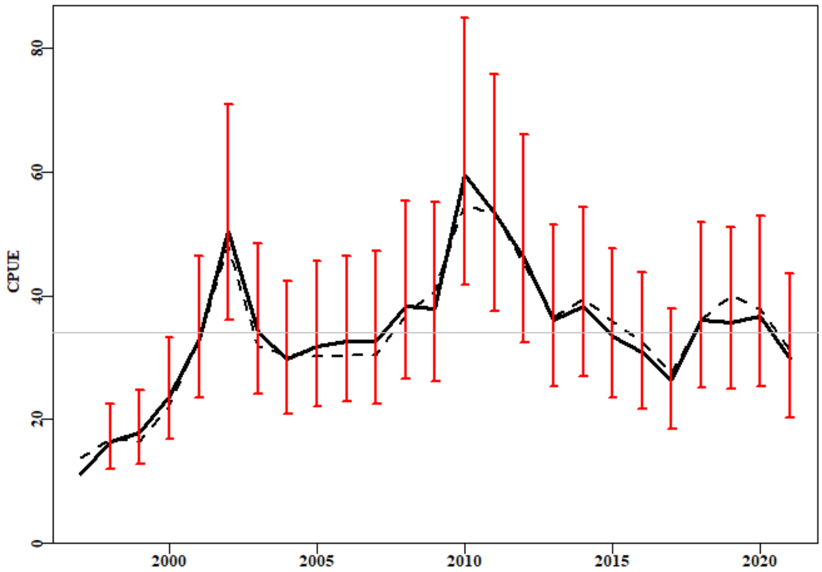

Figure 5. Standardised catch per unit effort in days (kg.day^{-1}) handlining for Yellowtail Kingfish for years 1997-98 to 2018-19 in NSW. The dashed line is the geometric mean CPUE while the solid line with 95% confidence intervals is the standardised CPUE. The horizontal line represents the average catch rate. Year is fiscal.

Trolling has accounted for 31% of the total Yellowtail Kingfish catch since 1997-98. There is no clear trend in standardised CPUE during the available reporting period (Fig. 6) and the 95% confidence intervals surrounding these values are relatively large and overlap with those from other years.

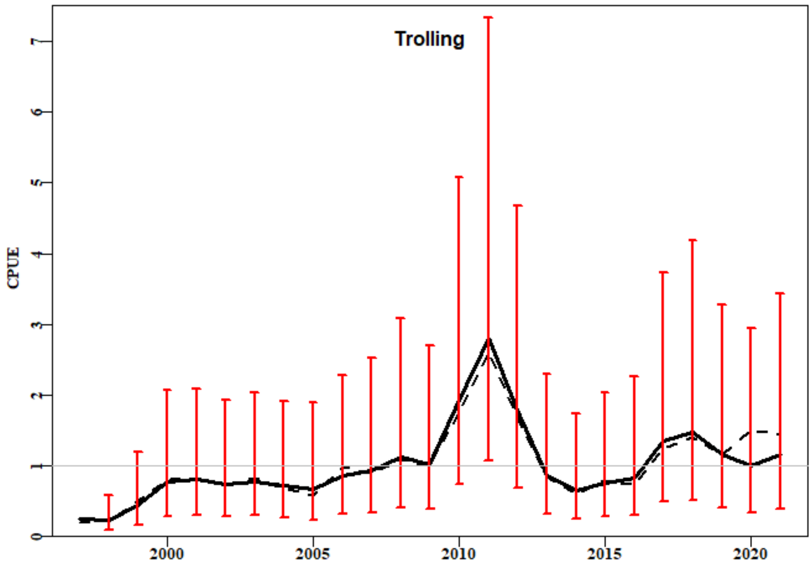

Figure 6. Standardised catch per unit effort in days (kg.day-1) trolling for Yellowtail Kingfish for years 1997-98 to 2018-19 in NSW. The dashed line is the geometric mean CPUE while the solid line with 95% confidence intervals is the standardised CPUE. The horizontal line represents the average catch rate. Year is fiscal.

Jigging has accounted for 8% of the total Yellowtail Kingfish catch since 1997-98. There is no clear trend in standardised CPUE over the available reporting period (Fig. 7) and the 95% confidence intervals surrounding these values are large and overlap with those from other years.

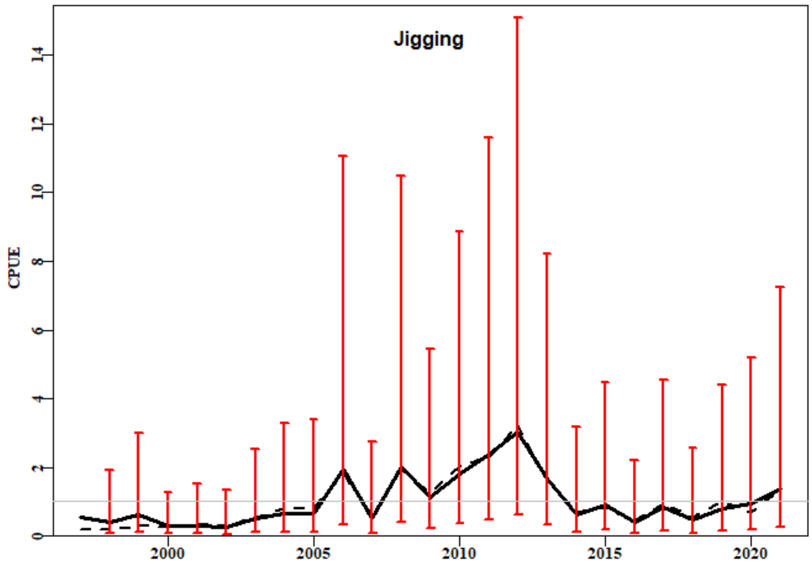

Figure 7. Standardised catch per unit effort in days (kg.day-1) jigging for Yellowtail Kingfish for years 1997-98 to 2018-19 in NSW. The dashed line is the geometric mean CPUE while the solid line with 95% confidence intervals is the standardised CPUE. The horizontal line represents the average catch rate. Year is fiscal.

Droplining has accounted for 8% of the total Yellowtail Kingfish catch since 1997-98. There is no clear trend in standardised CPUE over the available reporting period (Fig. 8) and the 95% confidence intervals surrounding these values are large and overlap with those from other years.

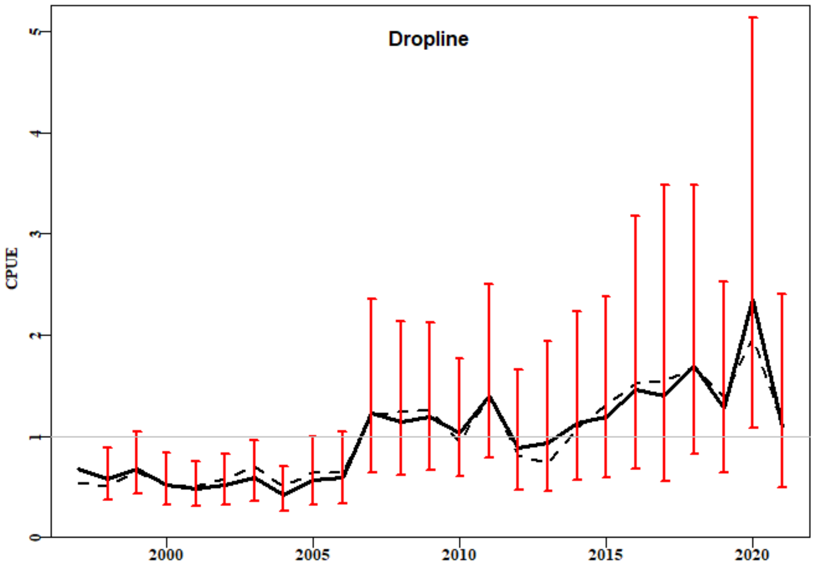

Figure 8. Standardised catch per unit effort in days (kg.day-1) droplining for Yellowtail Kingfish for years 1997-98 to 2018-19 in NSW. The dashed line is the geometric mean CPUE while the solid line with 95% confidence intervals is the standardised CPUE. The horizontal line represents the average catch rate. Year is fiscal.

2009-10 – 2020-21 (daily reporting)

Standardised catch per unit effort (kg.day^{-1}) was also estimated for commercial OTL line fishing methods (handlining, trolling, jigging, droplining, and all line fishing methods combined) using logbook data from the period 2009-10 – 2021-22 in which only days when Yellowtail Kingfish were landed were included. CPUE was standardized for variation across year, months, areas and vessels as described above.

The daily-based standardised CPUE time series for handlining showed a very similar trend to the monthly-based CPUE standardisation (Fig. 5) with a ~27% decrease from ~90 kg.day^{-1} to ~66 kg.day^{-1} between 2009-10 and 2021-22 (Fig. 9).

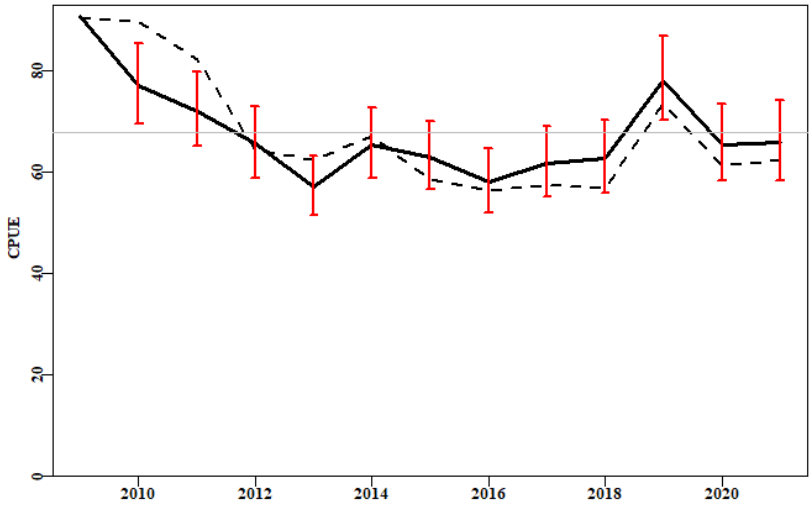

Figure 9. Standardised catch per unit effort in days (kg.day-1) handlining in which only days when Yellowtail Kingfish were landed for years 2009-10 to 2020-21 in NSW. The dashed line is the geometric mean CPUE while the solid line with 95% confidence intervals is the standardised CPUE. The horizontal line represents the average catch rate. Year is fiscal.

The daily-based standardised CPUE time series for trolling showed an initially decreasing trend to from 2009-10 to 2012-13, followed by an increasing trend to 2021-22, with an overall decrease of ~8% from ~150 kg.day^{-1} to ~138 kg.day^{-1} between 2009-10 and 2021-22 (Fig. 10).

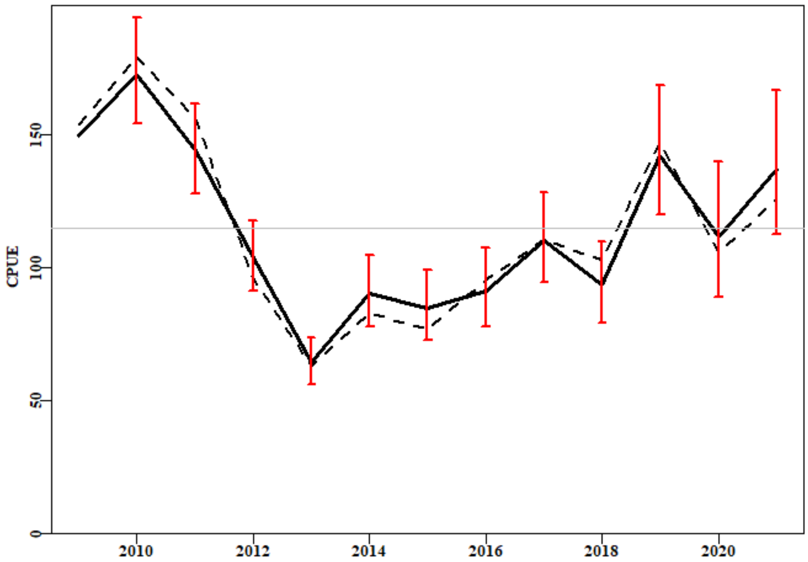

Figure 10. Standardised catch per unit effort in days (kg.day-1) trolling in which only days when Yellowtail Kingfish were landed for years 2009-10 to 2020-21 in NSW. The dashed line is the geometric mean CPUE while the solid line with 95% confidence intervals is the standardised CPUE. The horizontal line represents the average catch rate. Year is fiscal.

The daily-based standardised CPUE time series for jigging showed an initially decreasing trend from 2009-10 to 2013-14, followed by an increase to 2021-22, with an overall decrease of ~20% from ~150 $kg.day^{-1}$ to ~120 $kg.day^{-1}$ between 2009-10 and 2021-22 (Fig. 11).

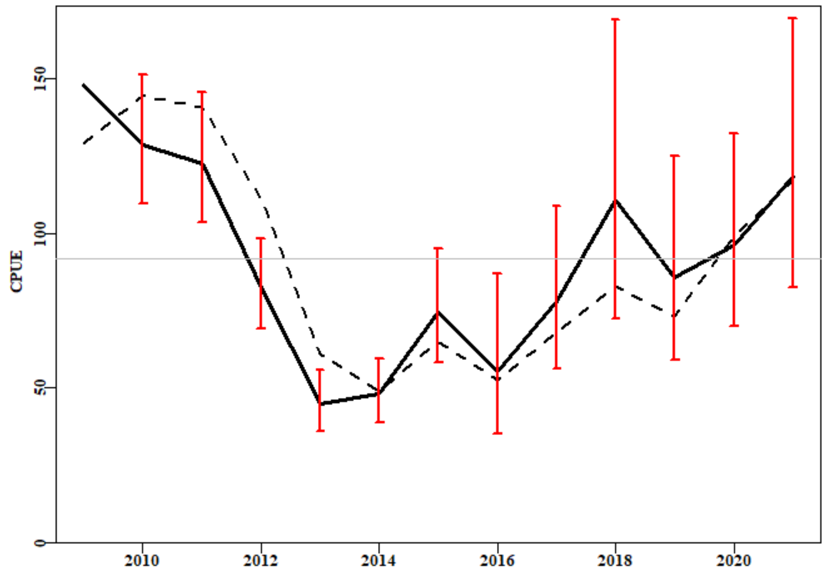

Figure 11. Standardised catch per unit effort in days (kg.day-1) jigging in which only days when Yellowtail Kingfish were landed for years 2009-10 to 2020-21 in NSW. The dashed line is the geometric mean CPUE while the solid line with 95% confidence intervals is the standardised CPUE. The horizontal line represents the average catch rate. Year is fiscal.

The daily-based standardised CPUE time series for droplining showed a period of relative stability between 2009-10 and 2016-17, followed by an increasing trend to 2021-22, with an overall increase of ~120% from ~50 $kg.day^{-1}$ in 2009-10 to ~110 $kg.day^{-1}$ in 2021-22 (Fig. 12).

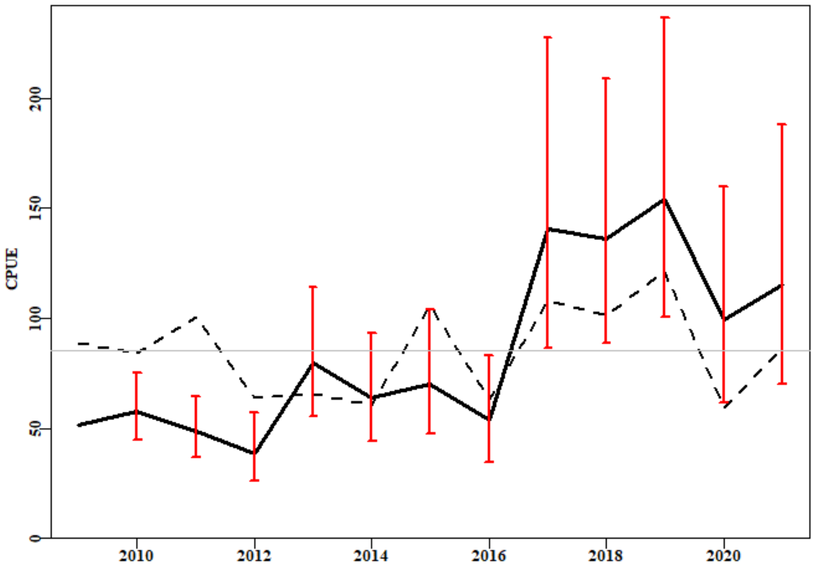

Figure 12. Standardised catch per unit effort in days (kg.day-1) droplining in which only days when Yellowtail Kingfish were landed for years 2009-10 to 2020-21 in NSW. The dashed line is the geometric mean CPUE while the solid line with 95% confidence intervals is the standardised CPUE. The horizontal line represents the average catch rate. Year is fiscal.

When daily-based standardisation of CPUE was applied to all linefishing methods combined, the time series showed similar pattern to that for handlining (Fig. 9), with an initially decreasing trend from 2009-10 to 2013-14, followed by a slight increase to 2021-22, with an overall decrease of ~28% from ~110 kg.day^{-1} to ~80 kg.day^{-1} between 2009-10 and 2021-22 (Fig. 13).

Figure 13. Standardised catch per unit effort in days (kg.day-1) for all lining methods combined in which only days when Yellowtail Kingfish were landed for years 2009-10 to 2020-21 in NSW. The dashed line is the geometric mean CPUE while the solid line with 95% confidence intervals is the standardised CPUE. The horizontal line represents the average catch rate. Year is fiscal.

Standardised commercial CPUE adjusted for logbook change and fishing power

To adjust for a logbook change from monthly to daily reporting which occurred in 2009, standardised handline catch rates were scaled as described in Hughes & Stewart (2020). Standardised catch rates were then adjusted according to increases in fishing efficiency (power) for linefishing as described in Wortmann et al. (2018). The resulting time series of catch rates showed a rapid initial increase between 1997-98 and 2001-02 (following the banning of pelagic fish traps in 1996), a decrease to 2004-05, before an increase to 2008-09 (Fig. 14). Catch rates increased by ~85% between 1997-98 and 2008-09. From 2009-10, there was a decline to 2013-14, before a period of relative stability to 2021-22, with catch rates decreasing by ~30% between 2009-10 and 2021-22. Overall catch rates have therefore increased by ~13% between 1997-98 and 2021-22.

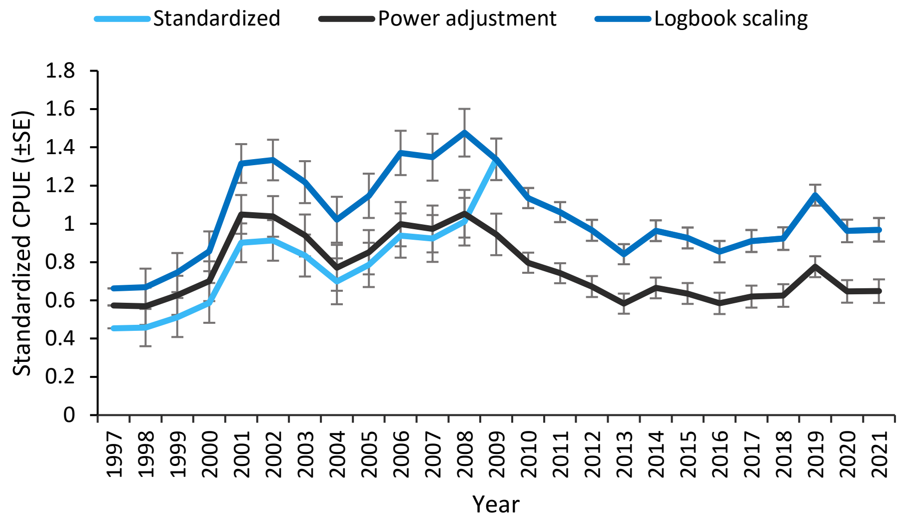

Figure 14. Standardized catch rate indices 1997-98 – 2021-22 using the method of handline for Yellowtail Kingfish (light blue) adjusted for: i) changes to logbook reporting (dark blue), and ii) increases in fishing power (black). Years are fiscal.

Length composition

The size composition of fish in commercial landings has remained relatively stable since the 1990s, except for the effect of increasing the minimum legal length in 2007 (Hughes & Stewart 2020). The fishery is based largely on juveniles (as there are few fish >85 cm FL in the catch – the size at maturity for female kingfish (Gillanders et al. 1999)). Around 90% of the catch is <85 cm FL, with the number of individuals >100 cm FL in the commercial catch over the past decade being consistently low (<1% per year on average) (Fig. 15).

The available size composition of recreational catches of Yellowtail Kingfish shows a similar pattern to that of the commercial catch. The most recent onsite recreational fishing survey carried out by NSW DPI found trailer boat catches of Yellowtail Kingfish in the Greater Sydney Region between 2007 and 2009 composed primarily (~88%) of individuals <85 cm FL (Steffe & Murphy 2011). The size composition of nearshore Charter Fishery catches of Yellowtail Kingfish in 2017-18 and 2019-20 was also similarly truncated with all fish measured between 60 and 95 cm FL size classes (Hughes et al. 2020, 2023).

Tagging data also indicates that the recreational fishery has been historically dominated by fish of immature sizes, with the vast majority of the ~40,000 Yellowtail Kingfish tagged and released in NSW as part of the NSW Fisheries Gamefish Tagging Programme between 1974 and 2022 being of immature sizes (Gillanders et al. 2001, Hughes & Stewart 2020, Goddard et al. submitted).

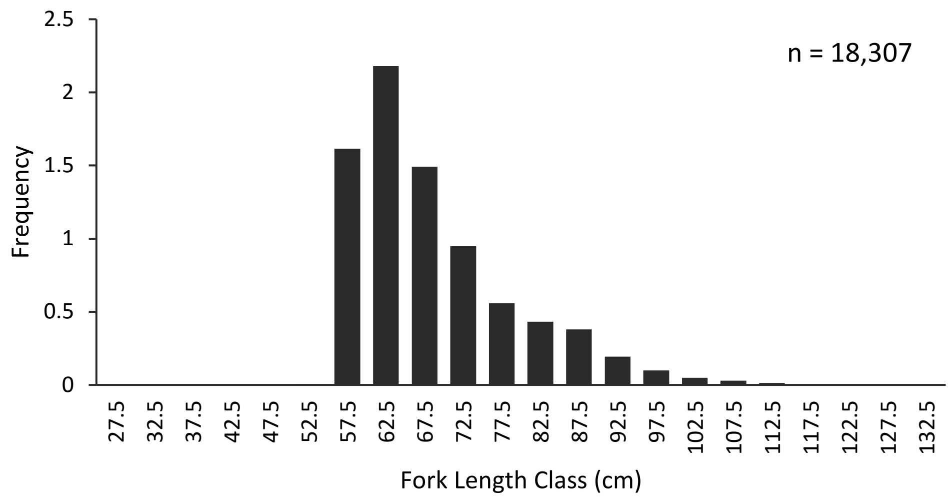

Figure 15. Size composition of the NSW commercial catch of Yellowtail Kingfish averaged from 2010-11 to 2021-22, weighted by reported landings for each year.

STOCK ASSESSMENT

Stock Assessment Methodology

Year of most recent assessment:

2023 (using data to 2021-22)

Assessment method:

A weight-of-evidence approach has been used to classify the biological status of the NSW Yellowtail Kingfish stock based on:

1) Standardised commercial linefishing catch rates (CPUE)
2) Surplus production modelling
3) Spawning Potential Ratio (SPR) modelling
4) Catch curve analysis
5) Length compositions

Main data inputs:

<u>Standardised Commercial CPUE</u>

- Standardised catch per unit effort (kg.day^{-1}) for the four main commercial methods landing Yellowtail Kingfish – handlining, jigging, trolling and droplining. CPUE was standardised for variations across months, areas and vessels to a mean estimate of CPUE by year for the periods 2009-10 – 2021-22 (daily reporting; Figs 5-8) and 1997-98 – 2021-22 (monthly reporting; Figs 9-13);
- Standardised handlining CPUE was also scaled to account for reporting changes, and adjusted for fishing efficiency (power) for 1997-98 to 2021-22 (Fig. 14).

Production model

- Historical catch series (Fig. 3), comprising:
  - Commercial OTLF landings reported in NSW from 1950-51-2021-22 (Fig. 1);
  - Annual estimates of recreational harvest in NSW from 2000 onward imputed from four available harvest estimates from state-wide telephone diary surveys (Fig. 2);
  - Annual estimates of recreational harvest in NSW during 1950-1999 imputed from the ratio of Yellowtail Kingfish harvest in NSW during the year 2000 to total Australian recreational harvest (Kleisner et al. 2015) (Fig. 2).
- Standardised commercial handlining CPUE scaled to account for reporting changes, and adjusted for fishing efficiency (power) for 1997-98 to 2021-22 (Fig. 14).

SPR model

- Length-composition data from NSW commercial OTLF 2011-12 – 2021-22 (Fig. 15);
- Biological parameters (natural mortality (M), fecundity, maturity, length-weight, growth parameters), selectivity, total (Z) and fishing mortality (F) estimates.

Key model structure & assumptions:

Standardised commercial CPUE

Standardised catch per unit effort (kg.day^{-1}) for the four main commercial methods landing Yellowtail Kingfish – handlining, jigging, trolling and droplining was estimated using a general linear model (LM) constructed using the ‘cede’ package (Haddon et al. 2018) in ‘R’ statistical software. CPUE was standardised for variations across months, areas and vessels to a mean estimate of CPUE by year from 1997-98 to 2021-22 (monthly reporting; Figs 5-8) and 2009-10 to 2021-22 (daily reporting; Figs 9-13). CPUE was also scaled to adjust for a logbook change from monthly to daily reporting which occurred in 2009 (Hughes & Stewart 2020) and adjusted according to increases in fishing efficiency (power) for commercial linefishing (Wortmann et al. 2018) (Fig. 14).

Assumptions: Annual CPUE is an index of relative abundance and not unduly influenced by other factors that are not accounted for through standardisation, scaling or adjustment.

Production model

Production modelling was conducted to provide a complementary assessment method that integrates catch data and abundance indices (CPUE), and does not rely on length or age composition data.

CMSY++ (Catch-Maximum Sustainable Yield++; Froese et al. 2021).

CMSY++ is an advanced Bayesian state-space implementation of a modified Schaefer surplus production model (BSM). The BSM method relies on catch time series and relative abundance data, such as catch/effort (CPUE) data. The BSM method generates estimates of the intrinsic growth rate of a population (r) along with an estimate of its carrying capacity (k); from these, time series of biomass (B) and fishing mortality (F) can be computed, including the biomass (B_{MSY}) from which maximum sustainable yield (MSY) can be extracted given F_{MSY}. The model was conditioned on catch and calibrated using a time-series index of abundance (standardised handlining CPUE; Fig. 14). The main advantage of BSM compared to other implementations of surplus production models is the focus on informative priors and the acceptance of short and incomplete (fragmented) CPUE data (Froese et al. 2017).

Assumptions: Productivity models assume average recruitment across all stock sizes, including stock sizes below half of B_{MSY}. However, if recruitment is indeed reduced at lower stock sizes, then production models and CMSY will overestimate production of new biomass and will underestimate exploitation rates. Priors for initial relative biomass in 1950-51 were 0.4 – 0.8, and for final relative biomass in 2021-22 at 0.1 – 0.5.

<u>SPR model</u>

SPR modelling was conducted to provide a complementary assessment method that does not rely on catch data or abundance indices (CPUE).

The spawning potential ratio (SPR) of a stock is defined as the proportion of the unfished reproductive potential left at any given level of fishing pressure (Goodyear 1993). The model is a length-structure model which uses the length structure of the population together with biological parameters and mortality rates to estimate the reproductive output of the fished population relative to the reproductive output of the population in the absence of fishing.

Total mortality (Z) estimates were made using the length-converted catch curve method (Caddy 1983) for approximate ages 2 to 9 (FLs of 57.5 to 97.5 cm). An averaged length distribution incorporating annual distributions between 2010-11 and 2021-22 weighted by commercial landings each year was used. Growth parameters were taken from the published Schnute growth model for Yellowtail Kingfish (Stewart et al. 2004). Ages 2 – 9 were selected in order to reflect the total mortality on age classes which comprised the vast majority of the fishery (Fig. 15).

Assumptions: The size composition of commercial landings is assumed to arise from logistic gear selectivity and is representative of the size composition of the stock. Sampling is from a population not affected by immigration or emigration, mortality is constant across ages and years, and sampling is not biased regarding any age classes.

Sources of uncertainty evaluated:

<u>Production model</u>

Sensitivity of the model to a range of alternative assumptions and model inputs was evaluated by implementing 12 additional model scenarios, including those that varied CPUE time series and catch reconstructions, outlined in Hughes & Stewart (2020).

<u>SPR model</u>

A 95% confidence interval around the estimate of Z was derived from the uncertainty around the slope of the catch curve. Mortality estimates were made using a plausible range of values for M (range 0.2 – 0.3, median 0.257; Cope & Hamel 2022, Hamel & Cope 2022).

Sensitivity of the SPR model to a range of alternative assumptions and model inputs was also evaluated by implementing three additional model scenarios that used other possible catch curve estimates of mortality (Z, F and M) to generate a range of alternative SPR estimates (Table 1):

1) Base case – Z estimated from the decending limb of the catch curve for ages 2 to 9 (the ages which make up the majority of the fishery; Fig. 18)

2) Scenario 2 – Z estimated from the decending limb of the catch curve for ages 3 to 9 (the ages which make up the majority of the fishery starting from the age at full recruitment)
3) Scenario 3 – Z estimated from the decending limb of the catch curve for ages 2 to 20 (all ages in the catch curve)
4) Scenario 4 – Z estimated from the decending limb of the catch curve for ages 3 to 20 (all ages in the catch curve starting from the age at full recruitment).

The size composition of commercial catches is used in calculation of mortality rates (catch curve analysis) and subsequent estimates of SPR. If the size composition of commercial landings is not representative of size composition of the stock, then mortality estimates (Z & F) will be inflated, and SPR models may produce pessimistic SPR estimates. A non-representative commercial length composition could occur if:

1) Fishers selectively target small fish and/or selectively avoid larger fish (e.g. for marketing reasons – price)
2) Large fish are less catchable than smaller fish because of gear selectivity, behaviour or distribution
3) Routine port-based sampling does not sample large fish (e.g. small fish are sent to major markets where they are they are measured, but large fish are sold locally)
4) Age has been systematically underestimated in old age classes (the age-length relationship is incorrect).

Status Indicators - Limit & Target Reference Levels

Biomass indicator or proxy	Standardised commercial handlining CPUE trends Current B/K from production model Current SPR from SPR model
Biomass Limit Reference Point	B_{20} (20% of pre-exploitation spawning biomass) SPR_{20} (20% of estimated unfished SPR)
Biomass Target Reference Point	NA
Fishing mortality indicator or proxy	Current F relative to F_{20} from production model Current total harvest relative to MSY from production model Current F relative to M from catch curve analysis
Fishing mortality Limit Reference Point	$F > F_{20}$ from production model Harvest > MSY from production model $F > M$ from catch curve analysis

Fishing Mortality Target Reference Point	NA

Stock Assessment Results

The NSW Yellowtail Kingfish stock is classified as **sustainable**. The status is based on:

1) Standardised handlining CPUE has increased overall by ~13% between 1997-98 and 2021-22 and has been relatively stable between 2013-14 and 2021-22 (Fig. 14).
2) Current biomass is estimated >20% of pre-exploitation biomass in the base case scenario of the production model – **B/K = 26%** (95% CIs 16-46%; Fig. 16).
    a. B/K > 20% in most model scenarios (Hughes & Stewart 2020)
3) Current SPR is estimated >20% of unfished SPR (SPR_{20}) using median M (0.257) in the base case scenario SPR model – **SPR = 22%** (range 12-33%; Table 1).
4) Current F is estimated < F_{20} in the base case scenario of the production model – **F/F_{20} = 0.61** (Fig. 17).
    a. F/F_{20} < 1 in most model scenarios (Hughes & Stewart 2020)
5) Current harvest (183 t) < MSY (416 t) in the base case scenario of the production model.
    a. Harvest < MSY in all model scenarios (Hughes & Stewart 2020)
6) Current F is estimated < median M (0.257) from catch curve analysis – for ages 2 to 9 total mortality – **Z = 0.46** (95% CIs 0.32-0.59; Fig. 13), current fishing mortality **F = 0.20** (range 0.16-0.26; Table 1).

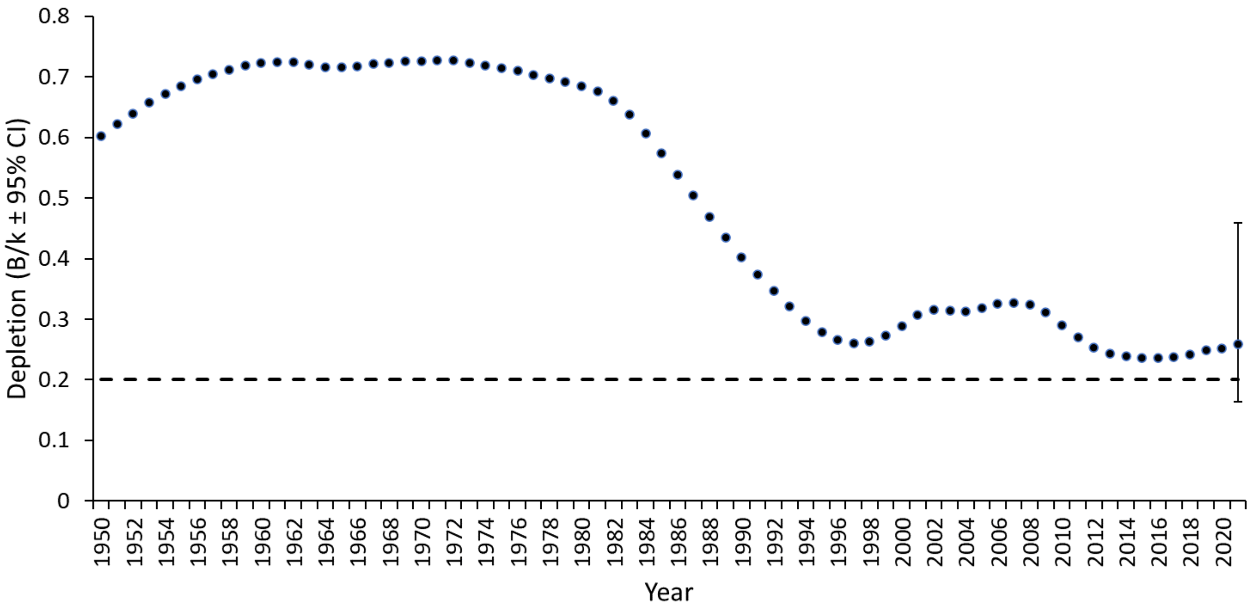

Figure 16 Depletion trajectory (B/K) for the base case catch and CPUE timeseries used in the production model for the period 1950-51 – 2021-22. A 95% CI is given for the current (2021-22) estimate. The dashed black horizontal line indicates the limit reference point of 20% B/K. Years are fiscal.

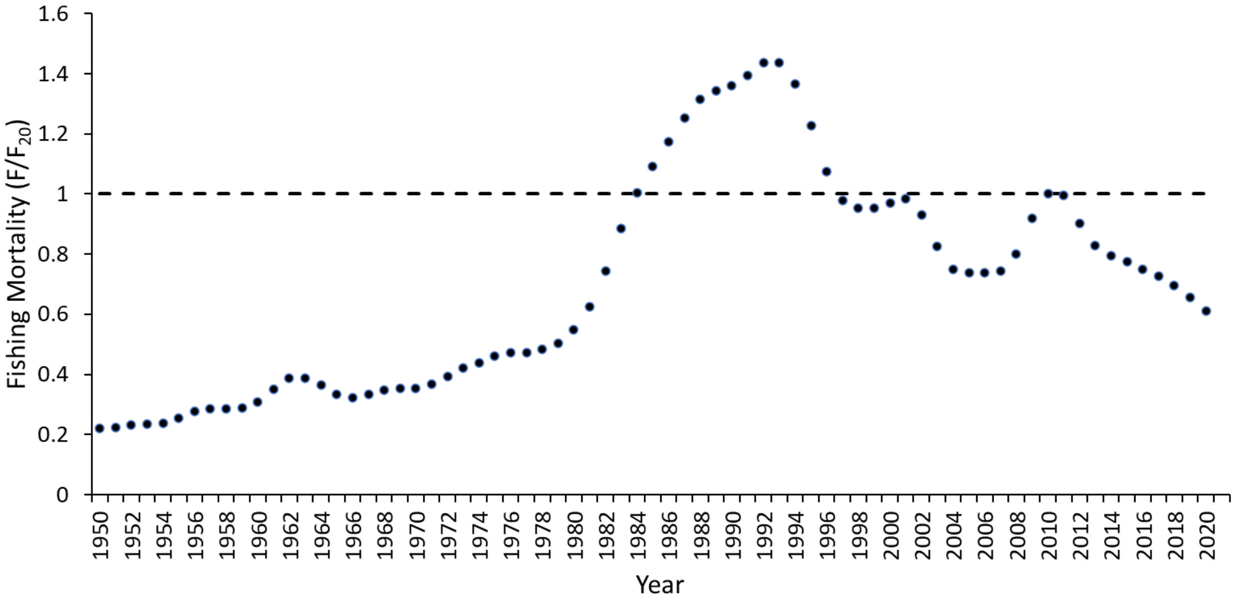

Figure 17 **F/F_{20} trajectory for the base case catch and CPUE timeseries used in the production model for the period 1950-51 – 2021-22. The dashed black horizontal line indicates the limit reference point of $F/F_{20} = 1$. Years are fiscal.**

Figure 18. Length-converted catch curve for Yellowtail Kingfish 2010-11 – 2021-22 indicative of a fishery where older fish are less vulnerable to exploitation due to distribution. The slope between ages 2 to 9 (base case Z) is 0.46.

Results of uncertainty evaluation

Standardised commercial handline CPUE adjusted for reporting changes and increases in fishing power

To account for increases in fishing efficiency (power), standardised handlining CPUE was also adjusted as described in Wortmann et al. (2018). The resulting time series of catch rates showed a ~85% increase between 1997-98 and 2008-09 followed by a ~30% decrease between 2009-10 and 2021-22. Overall catch rates have therefore increased by ~13% between 1997-98 and 2021-22 (Fig. 14).

Production model

Sensitivity scenarios run for the production model consistently estimated the current depletion of biomass to be above the limit reference point of 20% B/K using the most plausible catch reconstructions and CPUE timeseries, but all estimates' 95% CIs encompassed the limit reference point of B_{20} (Hughes & Stewart 2020). Two sensitivity scenarios (using modified or truncated CPUE timeseries) produced median estimates slightly below B_{20} (Hughes & Stewart 2020).

SPR model

It is considered that one of the four scenarios which may produce a non-representative length frequency are likely to occur for commercially-caught Yellowtail Kingfish in NSW (2. Large fish are less catchable because of distribution). All mortality rates derived from catch curve analysis are therefore likely to be inflated, and SPR estimates are likely to be pessimistic.

Sensitivity scenarios run for the base case SPR model using a range of M estimates (0.2-0.3) produced SPR estimates of 12-33% of unfished, which spans the biomass limit reference point of 20% unfished (SPR_{20}). As described above, sensitivity scenarios using alternative catch curve estimates of mortality produced SPR estimates that were highly pessimistic because of the likely non-representative nature of the length composition data for NSW Yellowtail Kingfish (Table 1).

Table 1. Z, F and SPR estimates in 2021-22 derived from the base case and three alternative catch curve scenarios used in the SPR model. Estimates were made using a plausible range of values for M (range 0.2 – 0.3, median 0.257; Cope & Hamel 2022, Hamel & Cope 2022). The limit reference point is 20% SPR. See "Sources of uncertainty evaluated: SPR model" above, for descriptions of sensitivity scenarios.

Sensitivity scenario	Ages used in catch curve	Z	Median F (range)	Median SPR (range) %
1 (base case)	2 – 9	0.457	0.199 (0.157 – 0.257)	22 (12 – 33)
2	3 – 9	0.535	0.328 (0.235 – 0.335)	14 (8 – 21)
3	2 – 20	0.761	0.503 (0.461 – 0 .561)	5 (3 – 7)
4	3 – 20	0.799	0.541 (0.498 – 0.598)	4 (2 – 6)

Stock Assessment Result Summary

Biomass status in relation to Limit	~13% increase in standardised handlining CPUE between 1997-98 and 2021-22 Production model (base-case, last series value [2021-22]): B/K = 26% SPR model (base case, last series value [2021-22]): SPR = 22%.
Biomass status in relation to Target	NA
Fishing mortality in relation to Limit	Production model – $F/F_{20} < 1$ (base-case, last series value [2021-22] = 0.61) Production model – Harvest < MSY (base-case, last series value [2021-22]) = 183 t (MSY= 416 t) Catch curve analysis – F < M (last series value [2021-22] = 0.20)
Fishing mortality in relation to Target	NA
Previous SAFS stock status	"Growth Overfished" in NSW assessments 2003-04 – 2013-14 "Uncertain" (Growth Overfished/Recruitment Overfished) in NSW assessment 2014/15 Eastern Australia stock "Undefined" SAFS 2014 Eastern Australia stock "Undefined" SAFS 2016 Eastern Australia stock "Undefined" SAFS 2018 Eastern Australia stock "Sustainable" SAFS 2020
Current SAFS stock status	Sustainable (Eastern Australia)

Fishery interactions

The "Eastern Australia" Yellowtail Kingfish stock is fished in the adjacent waters of Queensland, Victoria, Tasmania, and South Australia, as well as in the Commonwealth Southern and Eastern Scalefish and Shark Fishery (SESSF) and in the South Pacific Regional Fisheries Management Organisation (SPRFMO) Convention Area, and New Zealand.

Qualifying Comments

The size composition of landings indicates that the NSW fishery is dominated by immature individuals smaller than 85 cm FL, the approximate size at maturity for female Yellowtail Kingfish in NSW (Gillanders et al. 1999). Since routine commercial length frequencies have been generated for Yellowtail Kingfish in the 1990s, the size distribution of the catch has not changed, except for the effect of increasing the minimum legal length in 2007. A stakeholder survey conducted in 2020 indicated a perception that the NSW fishery currently contains fewer large fish (Stewart et al.

2021), however the size composition of fish in all available recreational and tagging datasets also indicates that the recreational fishery has been based largely on juveniles since at least the mid-1970s (Gillanders et al. 2001, Steffe et al. 1996, Steffe and Murphy 2011, Goddard et al. submitted). This long-term stability of the narrow size distributions seen in landings suggest that the stock is not fully mixed across its range (Green et al. 2020) and the ongoing source of recruits (mature spawning fish) are therefore not fully vulnerable to the NSW fishery, thus providing continuing recruitment which maintains the sustainability of the fishery. Numerous examples of long-distance movements of Yellowtail Kingfish have been recorded in this region, between Australia, New Zealand and Lord Howe Island as well as within Australia (spanning southern Queensland, NSW, Victoria, Tasmania and SA (Gillanders et al. 2001, Holdsworth et al. 2016, Goddard et al. submitted)). Consistent with these recorded movements, it has also been suggested that much of the spawning stock may be distributed offshore where it is not vulnerable to the NSW coastal fishery (Smith 1987, Gillanders et al. 1999, Gillanders et al. 2001, Patterson and Swearer 2008). Indeed, gravid female fish are routinely captured during the austral summer spawning season around Lord Howe Island (Patterson and Swearer 2008) but are relatively rare in NSW coastal waters during the same period (Gillanders et al. 1999) where the majority of the NSW fishery occurs. The temporal stability of these narrow size frequency distributions in NSW, which are used to derive estimates of mortality (from catch-curve analyses) and subsequent relative spawning stock biomass estimates (from length-based SPR modelling), are therefore likely to consistently indicate high mortality and reduced exploitable biomass through time. Analyses based on these size distributions are therefore unlikely to accurately represent the ongoing status of the entire “Eastern Australia” biological stock. The stability of this long-term pattern does, however, indicate ongoing recruitment into the NSW fishery, and in particular does not provide evidence to support predicted recruitment failure suggested by long term trends in SPR modelling (Hughes 2018).

It must be noted however, that this assumption comes with a risk; that if incorrect then it is possible that the part of the stock that occurs in NSW waters may be depleted to a level that may be below the limit reference level for recruitment overfishing (Goodyear 1993, Mace & Sissenwine 1993) as suggested by the range of length-based mortality rates and SPR modelling estimates. While analyses estimate that biomass to be greater than the 20% limit reference point in recent years, due to high variance surrounding estimates of all biomass indicators, none do so with high certainty, and it is therefore possible that recruitment impairment may be occurring. Results from data-limited assessment methods must therefore be interpreted with caution, given the limited information used to model population parameters and stock status for the entire “Eastern Australia” biological stock. Further work into examining the population dynamics of the stock in the region, and particularly investigating the distribution and movements of the spawning stock, as well as the source of juveniles, is currently underway to address this uncertainty (NSW DPI 2022, Goddard et al. submitted).

In addition, factors other than fishing, including climate change and other environmental processes, may also affect changes in the abundance and biological functioning of the Yellowtail Kingfish stock through time (Champion et al. 2018, 2019, Stuart-Smith et al. 2018).

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