Stock Status Summary – 2021/22

NSW Stock Status Summary – Bluespotted Flathead
(Platycephalus caeruleopunctatus)

Assessment Authors and Year

Hall, K. C. 2021. NSW Stock Status Summary 2021/22 – Bluespotted Flathead (*Platycephalus caeruleopunctatus*). NSW Department of Primary Industries, Fisheries. 21 pp.

Stock Status

Current stock status	On the basis of the evidence contained within this assessment, Bluespotted Flathead is currently assessed as **sustainable**.

Stock structure & distribution

Bluespotted Flathead is distributed along eastern Australia between southern Queensland and eastern Victoria, inhabiting deep estuarine and ocean waters to depths of about 100 m. The stock structure of Bluespotted Flathead has not been formally investigated and remains unknown. However, a review of the species' taxonomy that examined specimens from along the New South Wales coast and Lakes Entrance, Victoria, identified no significant variation in morphological characters within the species (Imamura 2015). Limited tagging data also suggest that, while some individuals show high site fidelity in estuarine habitats, other individuals cover large distances within a short period (Fetterplace et al. 2016), so some longshore mixing of populations is possible.

On the basis of this evidence, assessment of the stock status of Bluespotted Flathead is presented at the biological stock level – Eastern Australia.

Scope of this assessment

This stock assessment report provides a determination of the stock status for Bluespotted Flathead (*Platycephalus caeruleopunctatus*, CAAB 37 296007) according to the Status of Australian Fish Stocks (SAFS) framework, using data up to and including 2020/21. Only data from NSW are used to assess the stock status. While the species' distribution extends into Commonwealth, Queensland and Victorian waters, separate historical landings data are only available for NSW waters. Bluespotted Flathead is listed among the combined species taken under the basket Tiger Flathead TAC of the Commonwealth Southern and Eastern Scalefish and Shark Fishery (SESSF) in offshore waters south of Barrenjoey Point; however, recent landings data suggest that the species comprises a negligible (2.3–9.5 t) component of the total catch.

A total allowable commercial catch (TACC) was first introduced for Bluespotted Flathead for the NSW Ocean Trawl Fishery in state waters north of Barrenjoey Point in May 2019 and has been set at 108.1 t in the following three fishing seasons (Mapstone et al. 2020; NSW TAF Committee 2021). No catch quota was implemented for the Southern Fish Trawl Restricted Fishery in state waters south of Barrenjoey Point; however, those catches have been restricted by a combined flathead trip limit of 200 kg since 1996. Recreational and charter boat catches are limited by a daily bag limit of 10 (in total with Tiger Flathead, *Platycephalus richardsoni*) or 20 in possession, and all fisheries are restricted by a size limit of 33 cm total length (TL).

Biology

Bluespotted Flathead reaches a maximum size of about 68 cm TL and 3 kg in weight, with a pronounced sexual dimorphism. Females attain larger sizes than males at equivalent ages (Barnes et al. 2011). Males mature at about 1 year of age and 21 to 23 cm TL, while females mature later than males at 2 years of age and 28 cm TL in northern NSW and at 3 years of age and 35 cm TL in central NSW. The species is relatively fast growing and short lived, reaching a maximum recorded age of just 9 years.

Life history characteristics of Bluespotted Flathead vary significantly with water depth and latitude (Liggins 1996; Barnes et al. 2011; Barnes 2012). Juveniles (<25 cm total length, TL) are more common in inshore waters that are shallower than 30 m depth, while mature adults occur in deeper waters to 80 m depth. Because the shape of the continental shelf varies from wide and shallow along the north coast to narrow and steep along the south coast, the distribution and size structure of Bluespotted Flathead also varies, which in turn influences catches and discard rates along the NSW coast (Liggins 1996; Barnes et al. 2011; Barnes 2012).

FISHERY STATISTICS

Catch information

Commercial

Annual commercial catches of Bluespotted Flathead in NSW state waters are available from 1947/48 to present (Fig. 1). Early catches fluctuated considerably and then stabilised during the 1990s and 2000s at around 100–200 t per annum. Over recent years, catches decreased from 210 t in 2010/11 to 95 t in 2014/15, and then increased again to 146.2 t in 2017/18 and 123.5 t in 2018/19 before the TAC was introduced. In the two years since quota introduction, catches have been much smaller at 86 t in 2019/20 and 71.1 t in 2020/21 (Fig. 1). The prawn trawl component of ‘Flathead unspecified’ data are also included in the historical catch series, because anecdotal evidence from fishers suggest that these likely comprise mostly Bluespotted Flathead (Hall 2018).

Most of commercial catch of Bluespotted Flathead from NSW waters is taken by fish and prawn trawling in the Ocean Trawl Fishery (OTF) (Fig. 2). Since 1998, the proportion of catch taken by the prawn trawl sector in northern NSW (OZ1 to 3) has gradually decreased relative to that of the fish trawl sector in central NSW (OZ4 to 6) (Figs 2 and 3). The decrease in commercial catches between 2010/11 and 2014/15 and then increases during recent years have been due to fluctuations in the fish trawl sector, which accounted for 71.2% of the OTF catch in 2018/19. Catches along the south coast (OZ6–OZ10) by the Southern Fish Trawl Restricted Fishery have remained relatively stable, and only account for on average 10.6% of the total commercial catch (Figs 2 and 3).

Current discard rate estimates were applied to the annual catches in each sector to provide an historic series of estimated total discards for the fishery (Fig. 4) for use in the data-limited modelling approaches that rely on a robust catch history.

Figure 1. Annual total catch (tonnes) of Bluespotted Flathead for all sectors in NSW waters between 1947/48 and 2020/21. Data from 2020/21 are likely to be incomplete. Offshore catches are only included north of Barrenjoey Point (NofBJ) and data in some sectors (*) and years (1978/79–1989/90) have been adjusted. Recreational catch data are available from five surveys and are adjusted to statewide estimates. Charter boat data are only available since 2000/01 and included in recreational estimates in surveyed years. OPT=Ocean Prawn Trawl.

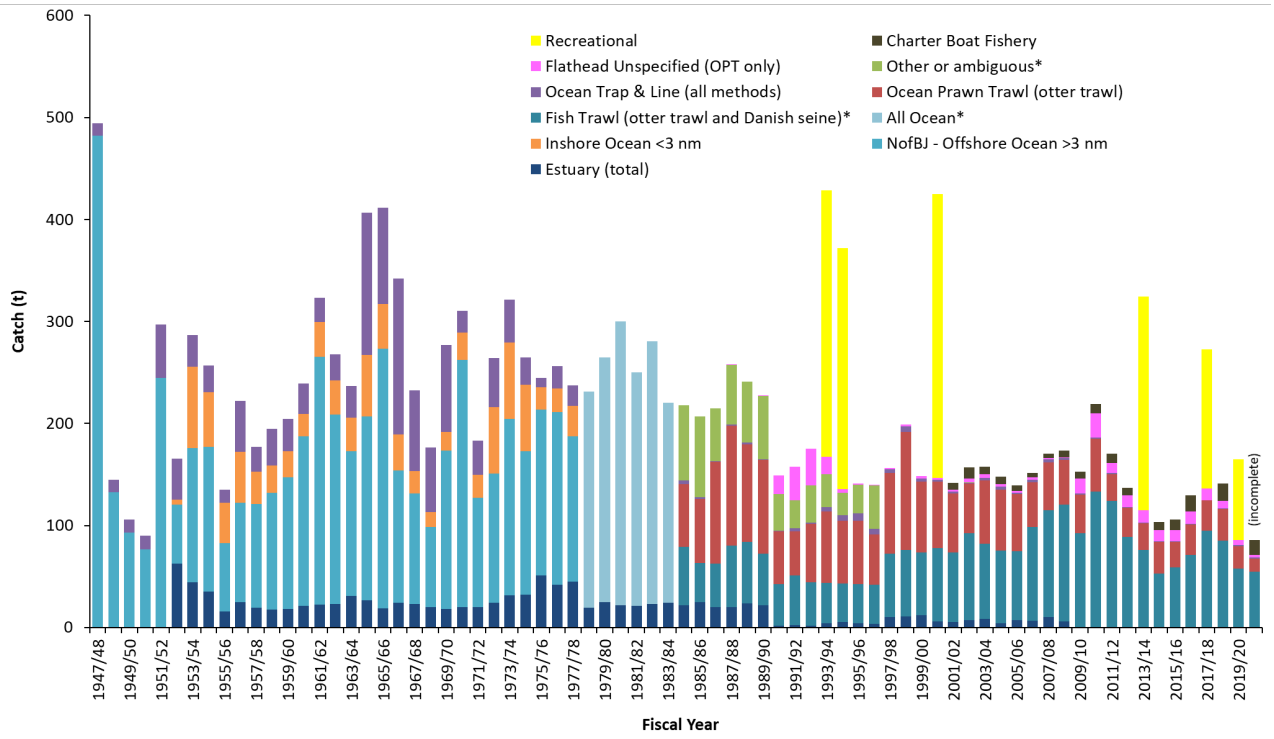


Figure 2. Annual commercial catches (tonnes) of Bluespotted Flathead in NSW waters (1997/98–2020/21) for different sectors of the NSW Ocean Trawl Fishery. OPT=ocean prawn trawl, NFT=northern fish trawl, SFT=southern fish trawl.

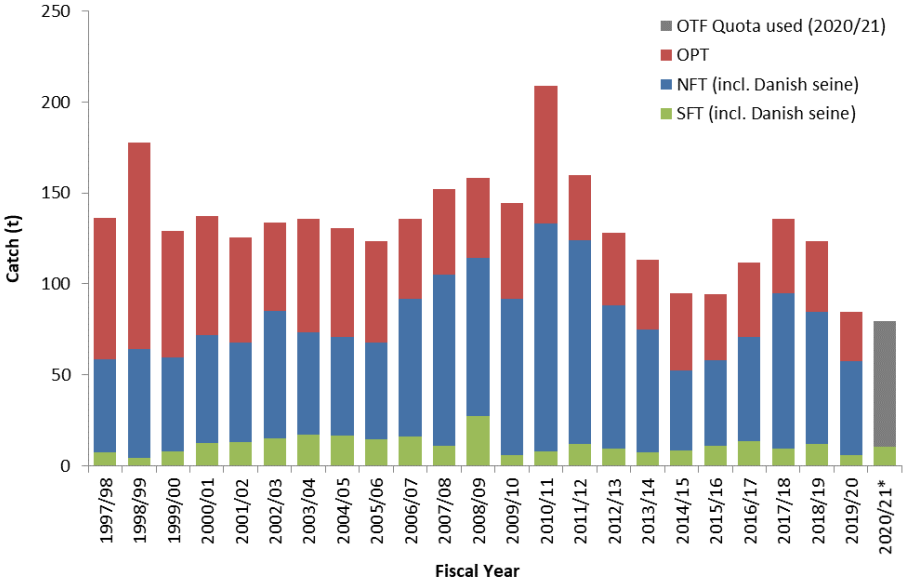


Figure 3. Annual commercial catches (tonnes) of Bluespotted Flathead from the NSW Ocean Trawl Fishery reported in different fishing zones (OZ1–OZ10), with catches in OZ6 divided into amounts taken from north and south of Barrenjoey Point (BJ) and zones south of BJ aggregated for confidentiality reasons.

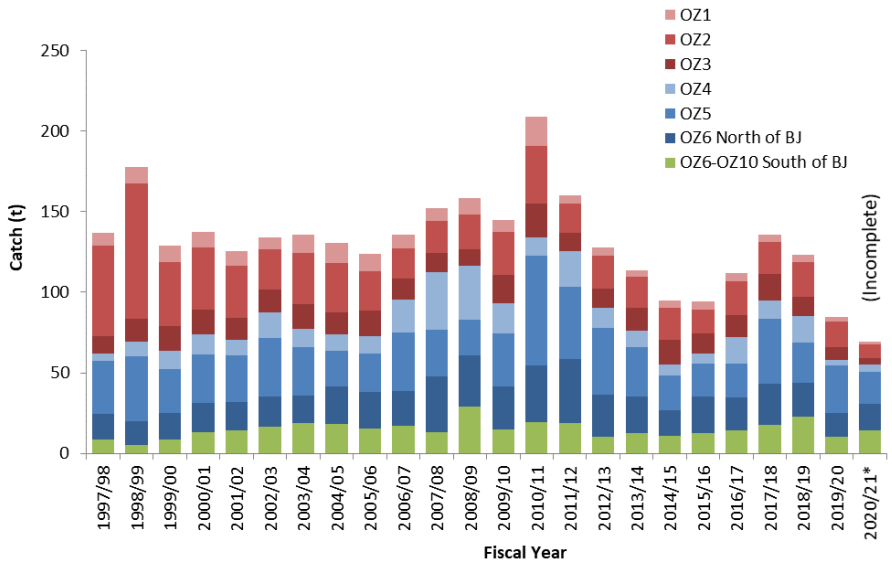
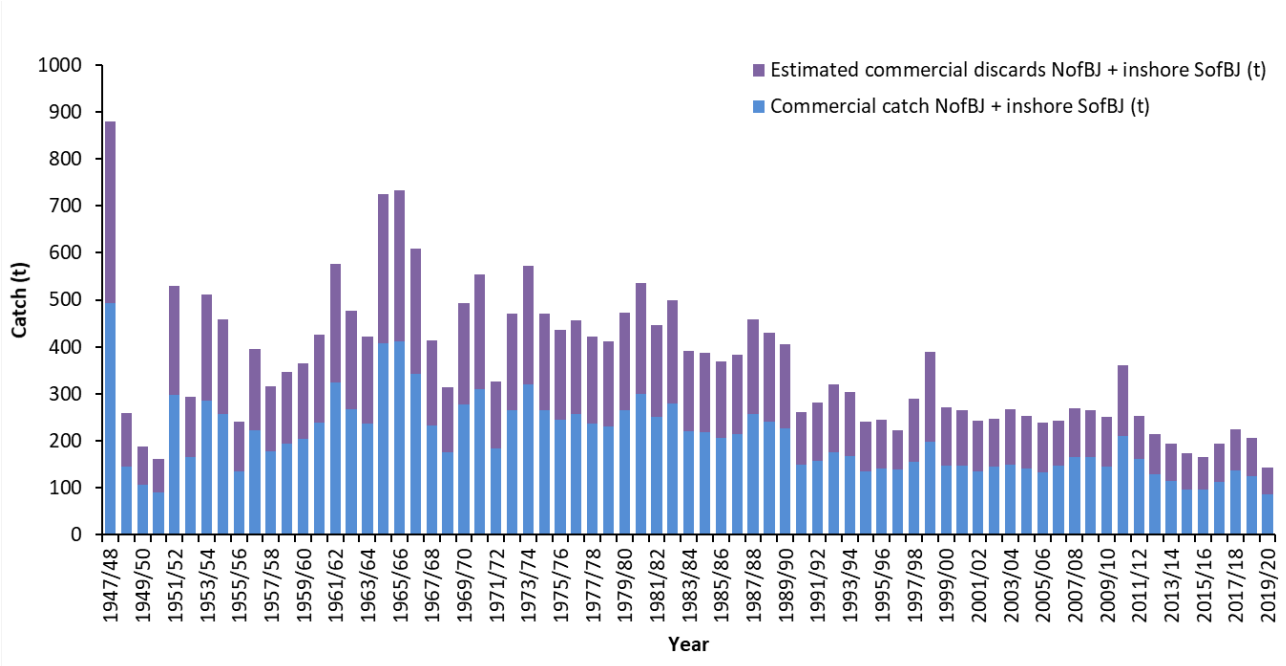


Figure 4. Total annual commercial catch of Bluespotted Flathead from NSW waters with estimated discards for the NSW Ocean Trawl Fishery. For catches and discards south of Barrenjoey Point only those from inshore State waters (<3 nm from coastline) have been included.



Recreational & Charter boat

The most recent estimate of the recreational harvest of Bluespotted Flathead (combined with other sand flatheads) in NSW was approximately 158,386 fish or around 72 t during 2019/20 (Murphy et al. 2020). This estimate was based on a survey of Recreational Fishing Licence (RFL) households, comprised of at least one fisher possessing a long-term (1 or 3 years duration) fishing licence and any other fishers resident within their household, excluding other long-term licence holders. This was 45% smaller than the equivalent estimated harvest in 2017/18 of around 363,949 fish or 129 t and 64% smaller than the estimated harvest in 2013/14 of around 416,195 fish or 199 t (Fig. 5) (Murphy et al. 2020). Relative to the commercial catch, the estimated statewide harvest of 210 t in 2013/14 accounted for approximately 64.6% of the total harvest of Bluespotted Flathead from NSW waters and 71.6% when catches by interstate fishers were also included; whereas, the commercial catch was marginally larger than the recreational harvest in 2019/20 (Hall 2018b).

Prior to 1993/94, no comprehensive estimates are available. Anecdotally, marine recreational fishing is thought to have mirrored the expansion in the number of trailer boats owned in NSW, which apparently increased from around the 1950s. To provide complete historic series of recreational catches for the modelling work, estimated catches prior to 1993/94 were reconstructed using three approaches: (1) estimated as a constant proportion (72%) of historic commercial catches based on the survey results from 1993/94; (2) scaled backwards in proportion to historic changes in the NSW population size to depict a gradually increasing rate of recreational fishing from 1947/48 to 1993/94; and (3) scaled backwards in proportion to estimates of national recreational marine fishing effort estimated from coastal population statistics and snapshot estimates of past participation rates (Kleisner et al. 2015). The three resulting series are shown in Fig. 6.

Bluespotted Flathead are one of the main target species in the NSW Charter Boat Fishery (Hughes et al. 2021). Reported catches from this sector are available from logbook reporting from 2000/01 to 2019/20. Catches remained at <10 t in most years since 2000/01, until recent increases to 15.2–16.7 t between 2016/17 and 2018/19. The catch in 2019/20 was considerably lower (9.2 t) than in the preceding three years, which may reflect the influence of Covid-19 on tourism operations during the end of the 2019/20 financial year. Catches increased again in 2020/21 to 14.4 t.

Figure 5. Estimated NSW statewide recreational harvest and discard weights of Bluespotted Flathead from surveys of recreational fishers between 1993/94 and 2019/20.

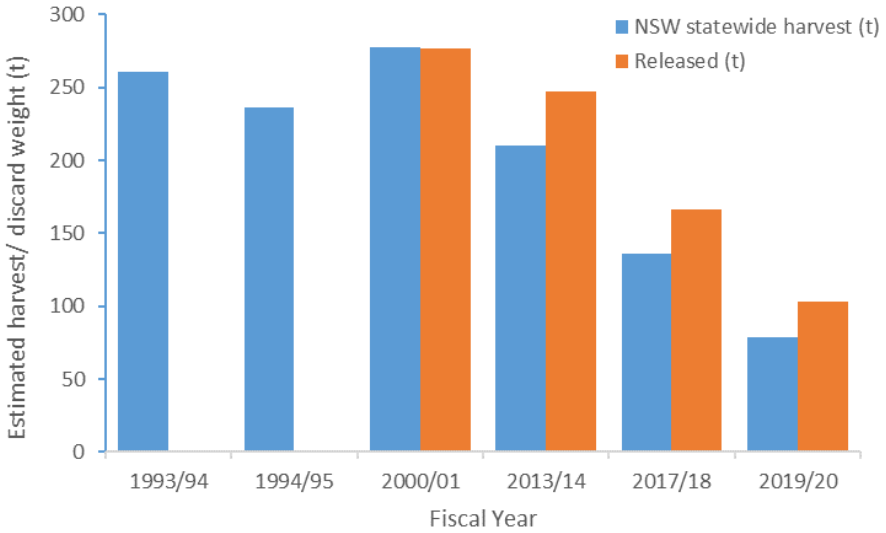
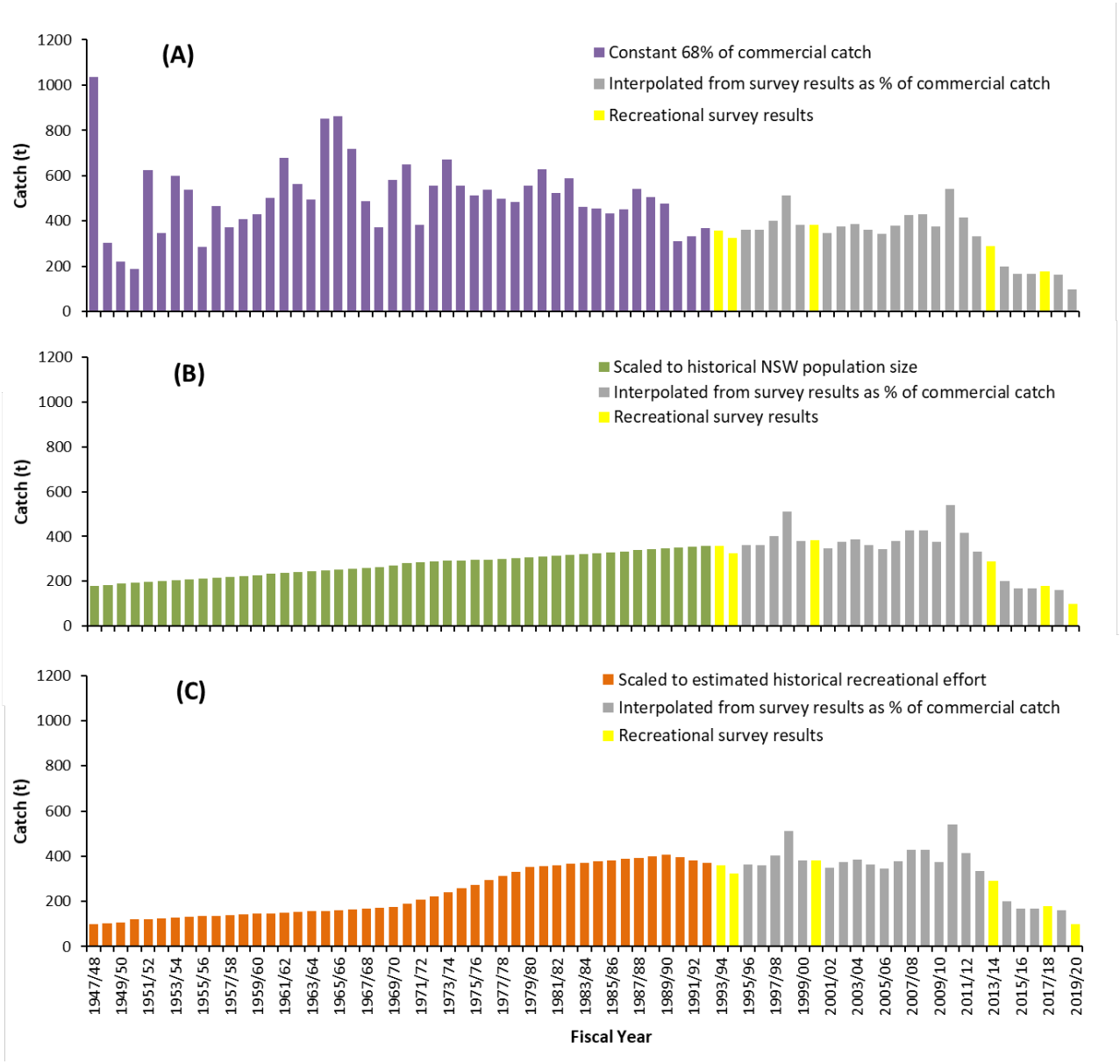


Figure 6. Estimated NSW statewide recreational harvests of Bluespotted Flathead from surveys of recreational fishers between 1993/94 and 2019/20 and hindcasted according to three different methods before 1993/94: constant 68% of commercial catch (top), scaled to historical NSW population sizes (middle) and scaled to historical estimated recreational effort according to the method by Kleisner et al. (2015).



Indigenous

The annual Aboriginal harvest of Bluespotted Flathead in NSW waters is currently unknown, but is assumed to be significant and requires quantification.

Illegal, Unregulated and Unreported

The level of illegal, unregulated and unreported (IUU) fishing is unknown; however, there is likely to be significant misreporting of Bluespotted Flathead as 'Unspecified Flathead' or 'Flathead (other)' in NSW waters (Hall 2018). To partially account for this discrepancy, the prawn trawl component of these unspecified catches has been included in the historical catch series. In 2019/20 this equated to 4.8 t, but has been as high as 24 t in 2010/11 and 35.4 t in 1992/93.

Fishing effort information

Commercial fishing effort for Bluespotted Flathead was collected as number of days fished on monthly records prior to July 2009 and as numbers of hours fished per daily event after July 2009. To form a longer time series of effort, recent daily events were re-aggregated, with effort in days fished estimated from the number of fishing events entered for each fisher in each month where Bluespotted Flathead was reported on at least one day; and were adjusted for multi-day trips reported as a single fishing event by dividing the total number of hours by 12.

Reported effort in the prawn trawl sector for Bluespotted Flathead rapidly decreased during the mid-2000s, and then remained more stable between 2009/10 and 2018/19 (Fig. 7). However, effort has rapidly decreased again following quota introduction. The reported effort in 2020/21 was 2,302 days and 229,80 h, which represents just 20.8% and 22.9%, respectively, of the effort reported in 1997/98. Reported effort in the fish trawl sector has declined more evenly over time, but has also rapidly declined over the last 2 years since quota introduction (Fig. 8). The reported effort for the fish trawl sector in 2020/21 was 538 days and 3,878 h.

Figure 7. Annual adjusted effort (days and hours fished) for prawn trawl fishers that reported landing Bluespotted Flathead on at least one day in each month. The vertical gold line indicates the change from monthly to daily event reporting.

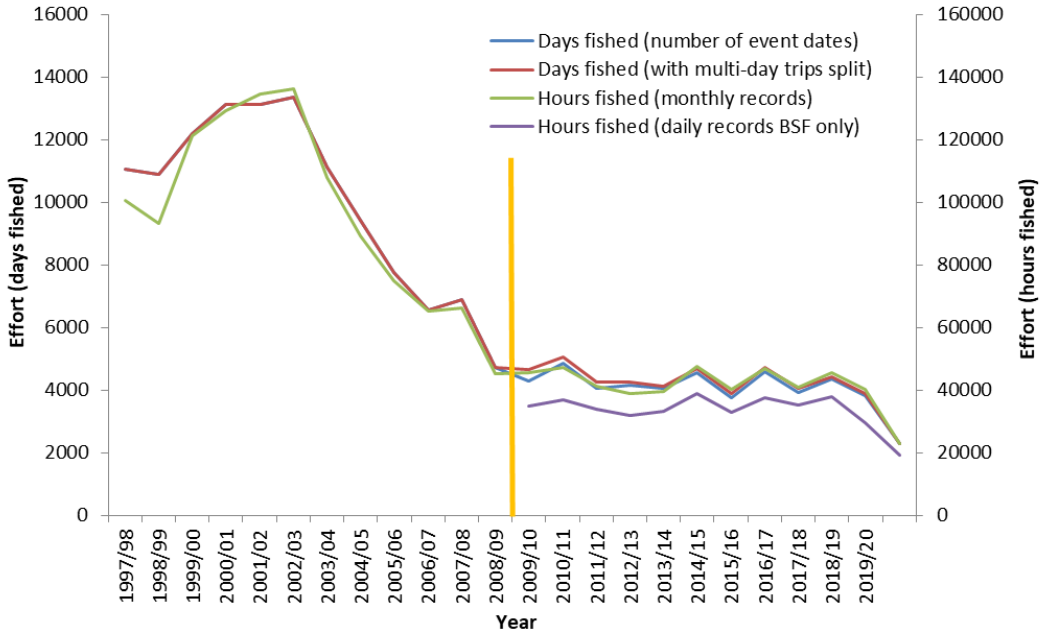
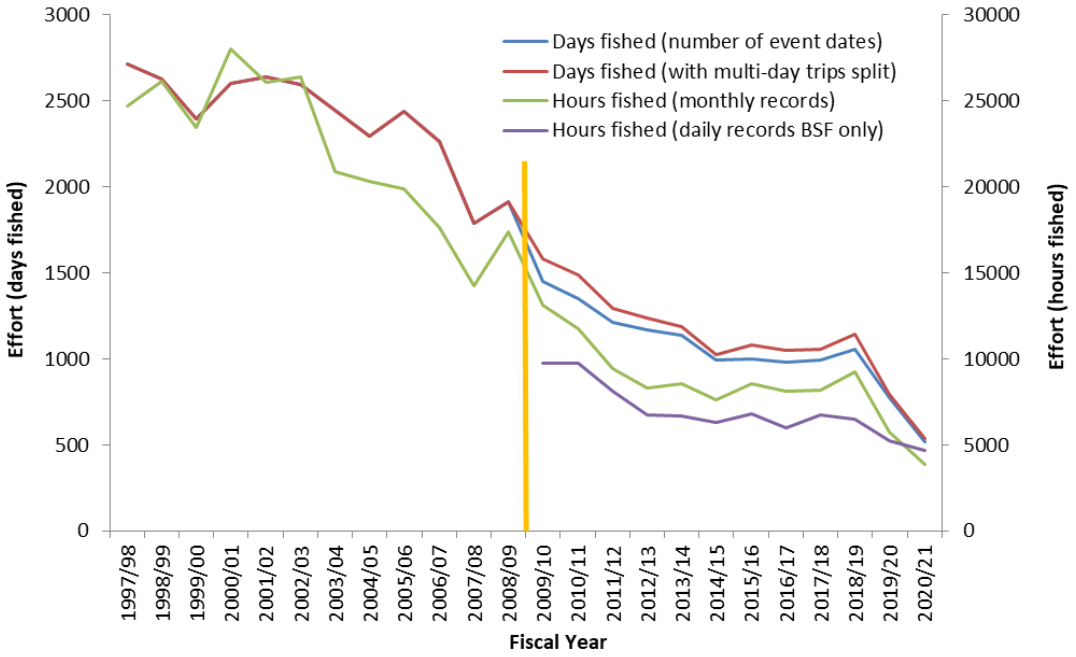


Figure 8. Annual adjusted effort (days and hours fished) for fish trawl (including Danish seine) fishers that reported landing Bluespotted Flathead on at least one day in each month. The vertical gold line indicates the change from monthly to daily event reporting.



Catch Rate information

Monthly catch rates (catch-per-unit-effort, CPUE in kg per day fished) for Bluespotted Flathead taken by the ocean prawn trawl and fish trawl (excluding Danish seine) sectors were compiled from monthly records between 1998 and 2008 and re-aggregated daily records between 2010 and 2020. Catch rates were standardized for month, ocean zone and vessel using the r-package 'cede' (Haddon 2018). Continuity of the time series across the catch reporting change in July 2009 must be interpreted with caution. Daily catch rates (CPUE in kg per hour trawled) were also compiled from daily fishing event records from 2010 to 2020 and standardised for month, ocean zone, vessel and capture depth (taken from the mean depth of the reported c-square).

The fish trawl sector consistently achieves higher mean catch rates (average of 77.8 kg per day) than the prawn trawl sector (average of 9.1 kg per day) (Figs 9 and 10). The two sectors operate in different ocean zones, use different gears and vary in their targeted fishing practices, which account for these differences.

Standardised catch rates for the ocean prawn trawl sector show similar patterns across the two different series (Fig. 9). Monthly catch rates rapidly declined by over 50% from 1998 to a minimum in 2002 and then gradually increased again between 2007 and 2010 up to a peak of 12 kg per day. Following a rapid decrease in 2011, catch rates remained steady near the long-term average until another sudden decrease in 2019 and 2020 (Fig. 9).

In contrast, recent trends in the standardised catch rates of the fish trawl sector vary across the two series analysed (Fig. 10). Monthly catch rates generally increased between 1998 and 2010,

before undergoing a steady decline to remain below the long-term average between 2014 and 2017. After that, recent monthly catch rates remained near or above the long-term average and steeply rose in 2020; whereas, the daily CPUE series tended to remain lower and just returned to the long-term average in 2020 (Fig. 10). These two fish trawl catch rates series were those used in the surplus production modelling (see below).

Anecdotal evidence from industry members suggests that the decline in prawn trawl catch rates may relate to increased discarding following quota introduction, with some large operators not securing sufficient flathead quota to cover incidental catches while targeting other species like whiting and prawns (that co-occur over similar grounds in northern NSW).

Catch rates for the Charter Boat Fishery (in number of fish per angler hour) have increased gradually over the last 19 years for which data are available (2001–2020, Fig. 11). However, catch rates in this sector are very low because total effort for each trip is used in their calculations, and flathead may be targeted for only part of the entire trip. Catch rates in 2019 and 2020 have been above the long-term average, despite the considerable drop in total catch in 2019, because it was accompanied by a similar drop in effort. Most of the charter catch derives from the south coast, where fish trawl catch rates have also recently been high.

Figure 9. Mean standardised catch rates (catch-per-unit-effort, CPUE) of Bluespotted Flathead for the ocean prawn trawl sector of the NSW Ocean Trawl Fishery, estimated from monthly records (1998–2009) and re-aggregated daily records (2010–2020) in kg per days fished and from daily fishing event records in kg per hour trawled. The dashed and solid lines indicate the nominal and standardised mean CPUE (± 95% confidence intervals), respectively and the grey horizontal line indicates the long-term average for each series.

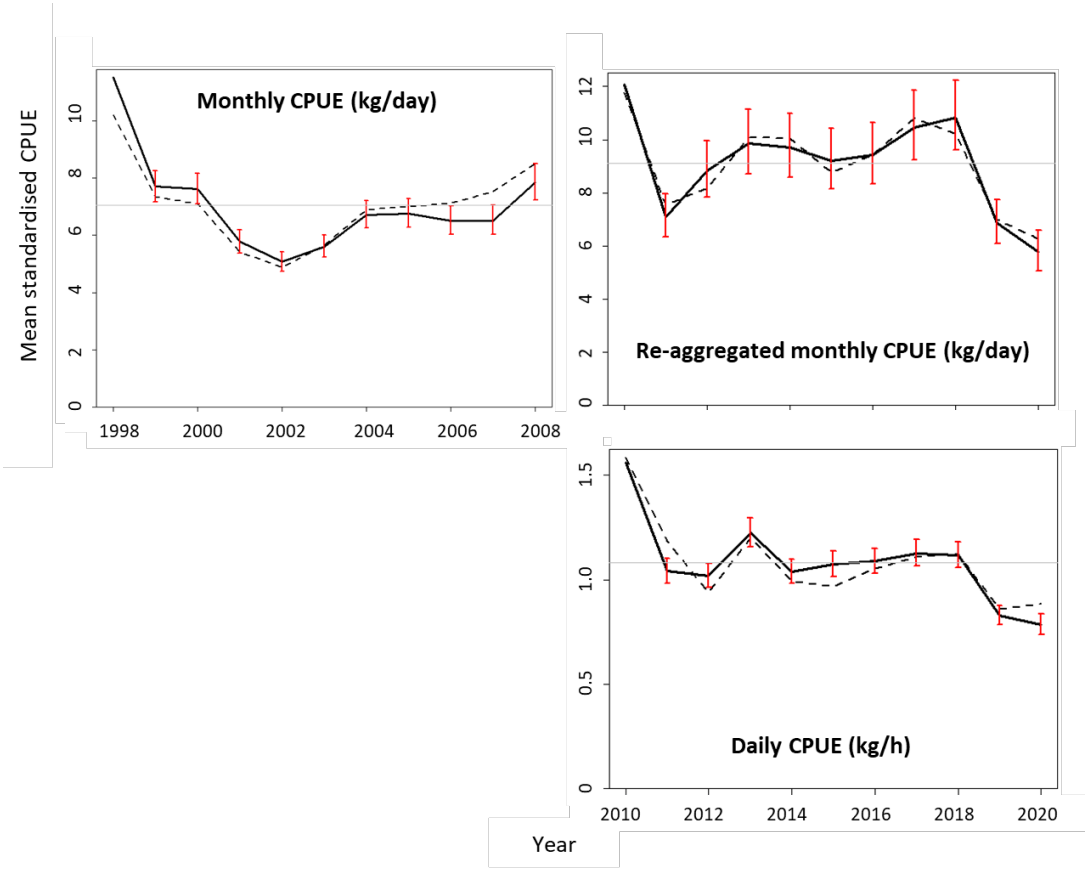


Figure 10. Mean standardised catch rates (catch-per-unit-effort, CPUE) of Bluespotted Flathead for the fish trawl (excluding Danish seine) sector of the NSW Ocean Trawl Fishery, estimated from monthly records (1998–2009) and re-aggregated daily records (2010–2020) in kg per days fished and from daily fishing event records in kg per hour trawled. The dashed and solid lines indicate the nominal and standardised mean CPUE (± 95% confidence intervals), respectively and the grey horizontal line indicates the long-term average for each series.

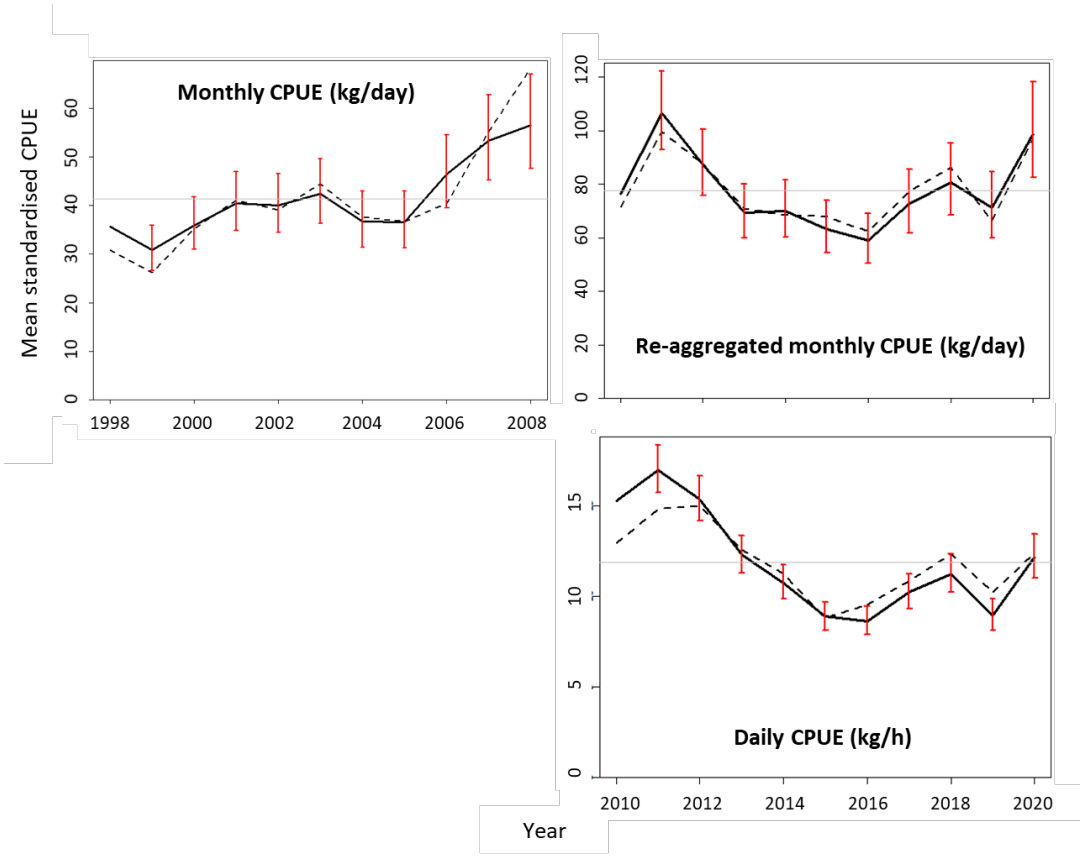
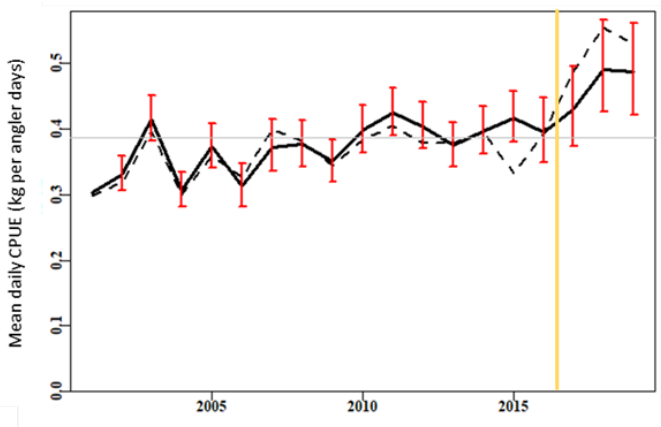


Figure 11. Mean standardised catch rates (fish per angler hour) of Bluespotted Flathead in the NSW Charter Boat Fishery (2001–2018). The dashed and solid lines indicate the nominal and standardised mean CPUE (± 95% confidence intervals), respectively and the grey horizontal line indicates the long-term average for each series, and the vertical gold line indicates the recent catch reporting change.



STOCK ASSESSMENT

This current assessment updates and builds on previous assessments between 2018 and 2020 (Hall 2018; Hall 2020; Hall 2021b) by combining the results from several data-limited approaches.

Stock Assessment Methodology

Year of most recent assessment:

2021 using data up to 2019/20 (Hall 2022).

Assessment method:

A weight-of-evidence approach was used for this stock assessment of Bluespotted Flathead in NSW waters. It incorporates the results from three different analyses:

1. Standardised catch rates for the two main commercial fishing fleets, fish trawl (otter trawl, excluding Danish seine) and prawn trawl (otter trawl), analysed by whole fleet and ocean zones, and the handline and rod sector of the Charter Boat Fishery;
2. Catch-curve analyses of age-structure data derived from length frequency data from 33 years to estimate fishing mortality levels - updated in 2021 (Hall 2022), with analyses of historical data completed in previous assessments (Hall 2018; Hall 2020; Hall 2021b); and
3. Catch-MSY and Bayesian state-space production model (BSM) analyses of 10 different historical catch and CPUE time series (spanning 1948/49 to 2019/20), comprising varying commercial, discard, recreational catch scenarios and CPUE time series for comparison (Froese et al. 2017).

Main data inputs:

Monthly catch rates (catch-per-unit-effort, CPUE in kg per days fished) calculated from commercial logbook data provided by fishers of the OTF for two methods – prawn trawl (otter trawl) and fish trawl (otter trawl) by calendar years (1998–2020).

Daily catch rates (CPUE in kg per hour trawled) calculated from commercial logbook data provided by fishers of the OTF for two methods – prawn trawl (otter trawl) and fish trawl (otter trawl) by calendar years (2010–2020).

Daily catch rates (CPUE in fish per angler hour) calculated from reported catch-and-effort data provided by fishers of the Charter Boat Fishery for the handline and rod fishing method by calendar years (2001–2020).

Length compositions - commercial catch samples via port monitoring (1969-1975 and 1999-2020, some years missing), onboard observer surveys (1990-1995 and 2014-2019) and independent trawl surveys by FRV Kapala (1990-1997).

Numbers-at-age data from the re-weighted length frequencies (as above).

Age–length keys developed from sectioned otoliths collected during onboard observer surveys (2014–2016) and fish sampled during port monitoring at seven locations (2016–2019) along the NSW coast.

Natural mortality estimates were derived using the updated Hoenig and Pauly equations recommended in Then (2014), a maximum age of 9 years and von Bertalanffy growth parameters determined from a reanalysis of data from Barnes et al. (2011) for both sexes combined. The updated Hoenig equation provided an estimate of M=0.33 and the updated Pauly equation an estimate of M=0.65. Given the disparity in these estimates, the average of M=0.49 was also used in analyses to provide a third comparison.

A resilience level of 'medium' was selected for Bluespotted Flathead on the basis of its life-history characteristics (i.e., maximum age of 9 years, early age-of-maturity and average natural mortality estimate of M=0.49, Froese et al. 2002)

Key model structure & assumptions:

The CPUE standardisations and analyses assume that the annual catch rates are a relative index of abundance and are not unduly influenced by other factors that are not accounted for through standardisation.

Fishing mortality estimates derived from catch-curve analyses are highly dependent on the availability of a sound estimate for natural mortality, which in the absence of alternative information is generally assumed to remain constant across years.

The modified Catch-MSY method is a model-assisted data-poor method that does not statistically fit an index of relative abundance to model the underlying population biomass. Rather it uses a form of stock reduction analysis and pre-determined parameter ranges for r and K and historical catches. The model is dependent on the resilience level and hence lower bound of r selected. Both modelling methods are subject to many other assumptions associated with the use of the simple Schaefer surplus production model, such as no variation in many parameters over time (Martell and Froese 2013; Froese et al. 2017; Haddon et al. 2018).

Sources of uncertainty evaluated:

Three different natural mortality estimates were used for the catch curve analyses.

Five different historical catch series were analysed for the modified Catch-MSY method, that differed with respect to whether or not estimated discards were included, and the temporal variation of recreational catch histories (Table 1). Two different CPUE series were analysed with the different historical catch series to provide 10 scenarios for the BSM analyses.

Table 1 Summary of the four catch and three catch-rate (CPUE) series used to construct 10 scenarios for Catch-MSY and BSM analyses of Bluespotted Flathead historical data.

No	Catch series	CPUE series
1	Comm	Separate monthly
2	Comm + discards	pooled average
3	Comm + discards + rec constant	
4	Comm + discards + rec scaled to NSW population size	
5	Comm + discards + rec scaled to historical effort	
6	Comm	Separate monthly
7	Comm + discards	and daily series
8	Comm + discards + rec constant	
9	Comm + discards + rec scaled to NSW population size	
10	Comm + discards + rec scaled to historical effort	

Status Indicators - Limit & Target Reference Levels

Biomass indicator or proxy	None specified in a formal harvest strategy. In the interim, a weight-of-evidence approach was used, which included: the mean estimated biomass depletion (as a percentage of the estimated unfished biomass, K) from Catch-MSY analyses and BSM analyses; and annual standardised catch rates from the fish trawl (otter trawl) and ocean prawn (otter trawl) sectors of the Ocean Trawl Fishery.
Biomass Limit Reference Point	None specified in a formal harvest strategy. In the interim, a default Blim of 20% of unfished spawning stock biomass was selected in line with the current NSW Harvest Strategy Policy (NSW DPI 2021).
Biomass Target Reference Point	None specified in a formal harvest strategy. In the interim, a Btarg of 48% of unfished spawning stock biomass was selected as a proxy for MEY in line with the current NSW Harvest Strategy Policy (NSW DPI 2021).
Fishing mortality indicator or proxy	None specified in a formal harvest strategy. In the interim, a weight-of-evidence approach was used, which included: the estimated mean annual relative fishing mortality from Catch-MSY and BSM analyses, and fishing mortality estimates from catch-curve analyses using length and age data sampled from commercial fisheries catches.
Fishing mortality Limit Reference Point	None specified in a formal harvest strategy. In the interim, the level of fishing mortality (Flim) above which overfishing is occurring and biomass is depleting toward Blim was selected.
Fishing Mortality Target Reference Point	None specified in a formal harvest strategy. In the interim, the level of fishing mortality (Ftarg) that would result in a spawning stock biomass of Btarg was selected.

Stock Assessment Results

Standardised catch rates

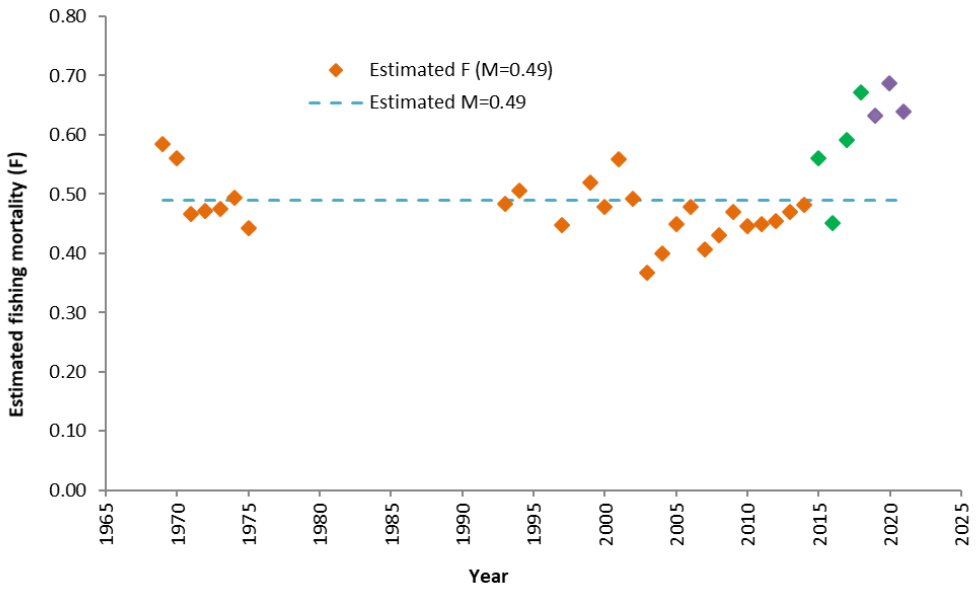
The standardised CPUE analyses produced some conflicting results, with prawn trawl catch rates in northern NSW declining substantially over the last two years, while fish trawl catch rates had recently increased. These fleet and spatial differences may relate to increased discarding among the prawn trawl fishers following quota introduction in May 2019, but need to be carefully monitored. Especially given that recent recreational catches have also declined that would not be influenced by quota introduction. Some spatial variation in catch rates across different ocean zones may also indicate some localised depletion is occurring (Hall 2022).

Size-structures, age-structures and catch-curve analyses

The length frequencies and mean lengths of Bluespotted Flathead sampled from NSW commercial catches have varied little over the 50-year period over which the historical data span (Hall 2020; Hall 2022). Recent data from the charter onboard observer program in 2017/18 and 2019/20 also show similar size structures to the commercial catches (Hughes et al. 2021).

Among the historical data, estimates of total mortality have also shown little variation across years (ranging from 0.86 to 1.07). However, catch-curve analyses of the most recent port monitoring samples produced slightly higher estimates of total mortality, and consequently fishing mortality (F=0.69 and 0.64 in 2019/20 and 2020/21), than in previous years that were above the average natural mortality estimate (M=0.49) (Fig. 12). However, interpretation of these results is sensitive to the assumed value of natural mortality selected and some hyperstability in the age structures may be resulting from the use of forward age-at-length analytic approaches for historical samples.

Figure 12. Estimated fishing mortality (F) from catch curves for Bluespotted Flathead in each calendar year (orange dots), recent observer surveys (green dots) and port monitoring fiscal years (purple dots), using an average natural mortality level (M=0.49). Sample numbers and sizes and fishing methods and locations have varied among years.



Catch-MSY and Bayesian state-space production models

Results of the Catch-MSY and Bayesian state-space production model (BSM) analyses produced varying biomass depletion estimates (26 to 72% of unfished biomass) depending on the catch history scenario and CPUE series combination selected, but all were above the limit nominated limit reference point of 20% of unfished biomass (Fig. 13, Table 2). The most likely scenario, involving commercial catches and discards, and recreational catches scaled to past NSW population sizes or recreational participation rates, combined with historical monthly catch rates and recent daily catch rates for the fish trawl sector, produced current biomass depletion estimates of around 40% of unfished biomass, with lower confidence bounds well above the limit reference point. In all cases, the lower confidence bound of the biomass depletion estimate were at or above the limit reference point.

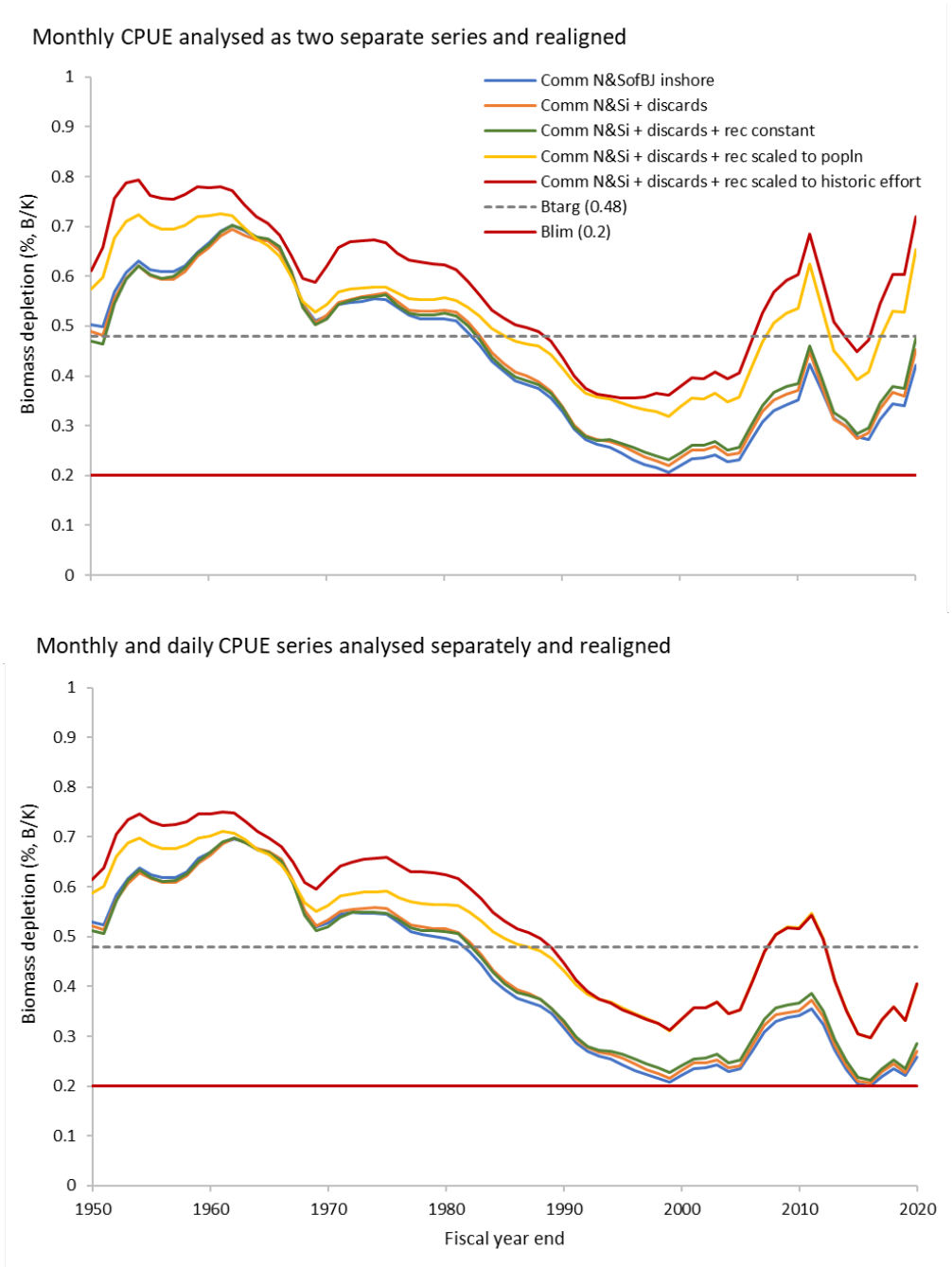
Irrespective of the analytic method or historical catch and CPUE series selected, all results suggested that the current harvest rate of Bluespotted Flathead in NSW waters is below that required to maintain the biomass at the level for MSY. Relative fishing mortality estimates (F/Fmsy) ranged between 0.23 and 0.72 depending on the historical catch and CPUE series combination selected (Table 2).

Table 2 Comparison of Catch-MSY and BSM results for five historical catch series of Bluespotted Flathead (from 1948/49 to 2019/20) and two CPUE series (from 1998 to 2020). Estimated parameters include the maximum sustainable yield (MSY) and current relative biomass depletion (B/K) and fishing mortality (F/Fmsy). An equivalent catch amount for the current OTF quota of 108.1 t north of Barrenjoey is provided for each catch series combination for comparison with the MSY estimates. Senarios 9 and 10 (highlighted in green) were considered the most likely combinations.

				CMSY						
No	Catch series	CPUE series	Equivalent for current quota	Lower CI	**MSY**	Upper CI	0.25 quantile	**B depletion**	0.975 quantile	F/Fmsy
1	Comm	N/A	120.7	201.4	238.6	275.1	0.14	0.48	0.57	0.37
2	Comm + discards		169.0	354.0	392.5	435.1	0.20	0.53	0.62	0.32
3	Comm + discards + rec constant		267.6	819.1	905.2	1000.3	0.16	0.50	0.61	0.25
4	Comm + discards + rec scaled popln		267.6	641.1	715.2	797.8	0.18	0.54	0.69	0.30
5	Comm + discards + rec scaled effort		267.6	633.7	714.7	805.9	0.25	0.62	0.70	0.26

				BSM						
No	Catch series	CPUE series	Equivalent for current quota	Lower CI	**MSY**	Upper CI	0.25 quantile	**B depletion**	0.975 quantile	F/Fmsy
1	Comm	Separate monthly pooled average	120.7	201.4	232.5	268.4	0.32	0.42	0.55	0.44
2	Comm + discards		169.0	327.8	378.9	437.9	0.34	0.45	0.58	0.39
3	Comm + discards + rec constant		267.6	778.8	880.6	995.6	0.37	0.47	0.60	0.28
4	Comm + discards + rec scaled popln		267.6	652.7	707.9	767.7	0.50	0.65	0.78	0.25
5	Comm + discards + rec scaled effort		267.6	655.7	707.0	762.5	0.54	0.72	0.85	0.23
6	Comm	Separate monthly and daily series	120.7	194.2	229.6	271.5	0.20	0.26	0.35	0.72
7	Comm + discards		169.0	316.7	375.8	446.0	0.20	0.27	0.36	0.66
8	Comm + discards + rec constant		267.6	751.8	871.8	1010.8	0.22	0.29	0.37	0.47
9	Comm + discards + rec scaled popln		267.6	622.1	691.9	769.5	0.29	0.40	0.59	0.42
10	Comm + discards + rec scaled effort		267.6	614.5	686.3	766.5	0.30	0.40	0.59	0.42

Figure 13. Results of Bayesian state-space surplus production model (BSM) analyses for various historical catch series of Bluespotted Flathead and (1) monthly CPUE analysed as two separate series and realigned across the change in catch reporting in 2009 (top); and (2) monthly and daily CPUE analysed as two separate series and realigned across the change in catch reporting in 2009 (bottom).



Stock Assessment Result Summary

Biomass status in relation to Limit	Results from the two data-limited stock assessment analyses (Catch-MSY and Bayesian state-space surplus production models, BSM) using the most likely historical catch and CPUE series combinations estimated the current spawning stock biomass of Bluespotted Flathead was around 40% of unfished biomass, with lower confidence bounds well above the nominate limit reference point of 20% of unfished biomass. For all scenarios analysed, the lower confidence bound of the biomass depletion estimate were at or above the limit reference point. The standardised CPUE analyses produced some conflicting results, with prawn trawl catch rates in northern NSW declining substantially over the last two years, while fish trawl and charter boat catch rates had recently increased. The size and age structures of fish sampled from the commercial catches and mortality estimates from corresponding catch-curve analyses over a period spanning 52 years have remained relatively stable. Overall, the weight-of-evidence indicates that the biomass of the stock is unlikely to be recruitment impaired; however, there is a high level of uncertainty in the assessment.
Biomass status in relation to Target	Relative biomass estimates varied widely with some results above or near the nominated reference point of 48%. All scenarios resulted in model outputs that suggested the biomass had decreased substantially between 1960 and 2000 and again more recently between 2010 and 2015. Results from the most likely historical scenarios, suggest that some stock rebuilding may be required to bring the stock back up to the potential target reference point.
Fishing mortality in relation to Limit	Results of model scenarios suggest that the current harvest rate of Bluespotted Flathead in NSW waters is below that required to maintain the biomass at the level for MSY. Relative fishing mortality estimates (F/Fmsy) ranged between 0.23 and 0.72 depending on the historical catch and CPUE series combination selected. The fishing mortality estimates from the length-converted catch-curve analyses spanning 52 years suggest that current levels are slightly higher than historic levels and slightly higher than natural mortality. Overall, the weight-of-evidence indicates that the current level of fishing pressure is unlikely to cause the stock to become recruitment overfished.
Fishing mortality in relation to Target	The stock assessment outcomes were uncertain with respect to where current fishing mortality levels are relative to the nominated target.
Current SAFS stock status	Bluespotted Flathead was assessed as **sustainable** under the SAFS framework in 2020 (Hall 2021a).

Fishery interactions

The OTF trawl fishing gears interact with other commercial and non-commercial by-catch marine species, a range of endangered, threatened and/or protected (ETP) species and marine habitats. The OTF share management plan mandates that otter trawl nets must be fitted with at least one BRD of an approved design to reduce the by-catch of small prawns and juvenile fish. Mesh size and other gear restrictions are regulated to increase the target species selectivity of otter trawl and Danish seine nets and cod ends. Research results to date suggest that these measures significantly decrease the levels of by-catch associated with these fishing gears (Broadhurst and Kennelly 1996; Broadhurst et al. 1996 ; Broadhurst et al. 1997; Broadhurst et al. 1999 ; Broadhurst et al. 2005; Broadhurst et al. 2006).

Interactions with animals protected under the *Environment Protection and Biodiversity Conservation Act* 1999 include marine mammals (dolphins, seals and sea lions), seabirds, some shark species, and seahorses and pipefish (sygnathids). The ETP species that interact with the OTF were subjected to a detailed risk assessment in the environmental impact statement (EIS) for the fishery (NSW DPI 2004). All 11 ETP species identified in the EIS were considered to be at moderate/low or low risk. An updated threat and risk assessment for all components of the NSW marine estate was completed in 2017 (Fletcher and Fisk 2017). The OTF was considered a moderate threat to ETP species along the north coast and a low threat to ETP species along the south coast. Interactions with grey nurse sharks and sygnathids were identified as the main concerns.

Compulsory reporting in commercial logbooks of all interactions with ETP species was mandated for the OTF in 2005 and these are reported annually to the Department of Environment and Energy (NSW DPI 2017). Data on incidental interactions with by-catch, ETP species and associated mortalities were also collected during a recent fish trawl (2014–2016) and prawn trawl (2017–2019) observer surveys.

The majority of available trawl ground in NSW waters is likely to be dominated by sandy habitat with little reef structure, and fishers typically try to avoid high topography, hard, structured habitats to prevent net damage. Large areas within NSW marine parks are closed to trawling and provide areas for habitat protection. The use of bobbins on ground ropes of fish trawl nets is prohibited north of Seal Rocks and the maximum size of bobbins is limited south of Seal Rocks to minimise damage to reef habitats. More information on the potential effects of trawl gears on the soft seabed biota is warranted, as impacts to these less protected habitats are likely to be more significant.

Qualifying Comments

The following are important points regarding this stock assessment to consider with respect to TACC determination:

- The modified Catch-MSY and BSM modelling approaches used in this assessment rely on simplistic and generic surplus production models, and results should be interpreted with caution.
- Future harvest rates should be set to allow for the high uncertainty in this assessment and ensure recovery of the biomass toward Btarg.
- Recent rapid decreases in prawn trawl catch rates and commercial and recreational catches need to be carefully monitored.
- Nevertheless, the stable size and age structures and fishing mortality estimates spanning 52 years suggest that current harvest rates are sustainable.

- The potential influence of catch reporting changes on commercial catch rates (especially during the transition from monthly to daily reporting around July 2009 and recently following quota introduction) complicates their use as an index of relative abundance.
- Ongoing misreporting of multi-day trips as single fishing events further compromise the accuracy of current catch-rate data.
- Recreational harvests of Bluespotted Flathead are significant and typically comprise over 50% of total landings from NSW waters.
- The uncertainty regarding the magnitude of, and temporal variation in, historical removals by the recreational sector increased the level of uncertainty in the Catch-MSY and BSM results.
- Likewise, the uncertainty around the accuracy of historical commercial catch data (especially prior to July 1990) and unknown temporal variation in discards should be considered when interpreting the Catch-MSY and BSM results.
- Discarding practices and rates are likely to have changed following the introduction of catch quota in May 2019 and the observer surveys for the OTF have now ceased. Increased discarding may be contributing towards the rapid decrease in commercial catch rates and catches observed over the last two years.
- There may also be unknown quantities of catch taken in other jurisdictions that overlap with the species' distribution that are reported in mixed species groupings.

References

Barnes, L. M. 2012. Comparative assessment of the growth, reproductive biology and life history characteristics of coexisting coastal flathead (Platycephalidae). PhD Thesis. Macquarie University, Sydney, Australia.

Barnes, L. M., C. A. Gray, and J. E. Williamson. 2011. Divergence of the growth characteristics and longevity of coexisting Platycephalidae (Pisces). Marine and Freshwater Research 62:1308-1317.

Broadhurst, M. K., and S. J. Kennelly. 1996. Effects of the circumference of codends and a new design of square-mesh panel in reducing unwanted by-catch in the New South Wales oceanic prawn-trawl fishery, Australia. Fisheries Research 27:203-214.

Broadhurst, M. K., S. J. Kennelly, and S. Eayrs. 1999. Flow-related effects in prawn-trawl codends: potential for increasing the escape of unwanted fish through square-mesh panels. Fishery Bulletin 97:1-8.

Broadhurst, M. K., S. J. Kennelly, and G. O'Doherty. 1996. Effects of square-mesh panels in codends and of haulback delay on bycatch reduction in the oceanic prawn-trawl fishery of New South Wales, Australia. Fishery Bulletin 94:412-422.

Broadhurst, M. K., S. J. Kennelly, and G. O'Doherty. 1997. Specifications for the construction and installation of two by-catch reducing devices (BRDs) used in New South Wales prawn-trawl fisheries. Marine and Freshwater Research 48:485- 489.

Broadhurst, M. K., R. B. Millar, M. E. L. Wooden, and W. G. Macbeth. 2006. Optimising codend configuration in a multispecies demersal trawl fishery. Fisheries Management and Ecology 13:81-92.

Broadhurst, M. K., D. J. Young, C. A. Gray, and M. E. L. Wooden. 2005. Improving selection in south eastern Australian whiting (*Sillago* spp.) trawls: effects of modifying the body, extension and codend. Scientia Marina 69:301-311.

Fetterplace, L. C., A. R. Davis, J. M. Neilson, M. D. Taylor, and N. A. Knott. 2016. Active acoustic tracking suggests that soft sediment fishes can show site attachment: a preliminary assessment of the movement patterns of the blue-spotted flathead (*Platycephalus caeruleopunctatus*). Animal Biotelemetry 4:1-11.

Fletcher, M., and G. Fisk. 2017. New South Wales marine estate threat and risk assessment report. Marine Estate Management Authority, Sydney, NSW.

Froese, R., N. Demirel, G. Coro, K. M. Kleisner, and H. Winker. 2017. Estimating fisheries reference points from catch and resilience. Fish and Fisheries 18:506-526.

Froese, R., M. L. D. Palomares, and D. Pauly. 2002. Estimation of life-history key facts. Pages 9 *in*. FishBase [Avaliable at www.fishbase.use/manual/English/KeyFacts.htm, Accessed on 5 December 2019].

Haddon, M. 2018. cede: functions for fishery data exploration and CPUE Standardization. R package version 0.0.4.

Haddon, M., A. Punt, and P. Burch. 2018. simpleSA: A Package containing functions to faciliate relatively simple stock assessments. R package version 0.1.13.

Hall, K. 2021a. Bluespotted Flathead *Platycephalus caeruleopunctatus*. T. Piddocke, and coeditors, editors. Status of Australian Fish Stocks Reports 2020. Fisheries Research and Development Corporation, Canberra, ACT.

Hall, K. C. 2018. Stock status summary and stock assessment report 2018 – Ocean Trawl Fishery (Inshore Prawn, Offshore Prawn, Deepwater Prawn and Northern Fish Trawl) – Bluespotted Flathead (*Platycephalus caeruleopunctatus*). NSW Department of Primary Industries, Coffs Harbour, NSW, Australia.

Hall, K. C. 2020. Stock assessment report 2019 – Ocean Trawl Fishery (Inshore Prawn, Offshore Prawn, Deepwater Prawn and Northern Fish Trawl) – Bluespotted Flathead (*Platycephalus caeruleopunctatus*). NSW Department of Primary Industries, Coffs Harbour, NSW, Australia.

Hall, K. C. 2021b. NSW stock assessment and status summary report 2020 – Ocean Trawl Fishery (Inshore Prawn, Offshore Prawn, Deepwater Prawn and Northern Fish Trawl) – Bluespotted Flathead (*Platycephalus caeruleopunctatus*). NSW Department of Primary Industries, Coffs Harbour, NSW, Australia.

Hall, K. C. 2022. NSW Stock assessment report 2021 – Ocean Trawl Fishery (Inshore Prawn, Offshore Prawn, Deepwater Prawn and Northern Fish Trawl) – Bluespotted Flathead (*Platycephalus caeruleopunctatus*). NSW Department of Primary Industries, Coffs Harbour, NSW, Australia.

Hughes, J. M., D. D. Johnson, J. J. Murphy, and F. A. Ochwada-Doyle. 2021. The NSW Recreational Fisheries Monitoring Program - Charter Fishery Monitoring 2017/18. NSW DPI - Fisheries Final Report Series No. 159. NSW Department of Primary Industries, Mosman, NSW, Australia.

Imamura, H. 2015. Taxonomic revision of the flathead fish genus *Platycephalus* Bloch, 1785 (Teleostei: Platycephalidae) from Australia, with description of a new species. Zootaxa 3904:151-207.

Kleisner, K., C. Brennan, A. Garland, S. Lingard, S. Tracey, P. Sahlqvist, A. Tsolos, D. Pauly, and D. Zeller. 2015. Australia: reconstructing estimates of total fisheries removals 1950-2010 Fisheries Centre Working Paper Series. Report No. 2015–02., Vancouver, Canada.

Liggins, G. W. 1996. The interaction between fish trawling (in NSW) and other commercial and recreational fisheries. FRDC Final Report Project No. 92/79. NSW Fisheries, Cronulla, NSW, Australia.

Mapstone, B., A. McDonald, R. Little, and S. Pascoe. 2020. Report and Determinations for the 2020–21 Fishing Period - -NSW Ocean Trawl Fishery: Blue-spotted Flathead, Tiger Flathead, Silver Trevally, and Eastern School Whiting and Stout Whiting. NSW Total Allowable Fishing Committee, Coffs Harbour, NSW.

Martell, S., and R. Froese. 2013. A simple method for estimating MSY from catch and resilience. Fish and Fisheries 14:504-514.

NSW DPI. 2004. Ocean Trawl Fishery Environmental Impact Statement. Public Consultation Document. NSW Department of Primary Industries, Cronulla, NSW.

NSW DPI. 2017. Assessment of the NSW Ocean Trawl Fishery. Prepared for the Department of Environment and Energy for the purpose of assessment under Part 13 and 13(A) of the Environment Protection and Biodiversity Act 1999. NSW Department of Primary Industries, Coffs Harbour, NSW.

NSW TAF Committee. 2021. Determination for the 2021/22 fishing period - -NSW Ocean Trawl Fishery: Eastern School Whiting, Stout Whiting, Bluespotted Flathead and Silver Trevally. NSW Total Allowable Fishing Committee, Coffs Harbour, NSW.

Then, A. Y., J. M. Hoenig, N. G. Hall, and D. A. Hewitt. 2014. Evaluating the predictive performance of empirical estimators of natural mortality rate using information on over 200 fish species. ICES Journal of Marine Science 72:82-92.