

Assessment Authors and Year

Liggins, G.W. 2021. NSW Stock Status Summary 2021/22 – Gemfish (*Rexea solandri*). NSW Department of Primary Industries, Fisheries. 15 pp.

Stock Status

Current stock status	On the basis of the evidence contained within this assessment, Gemfish are currently assessed as depleted .
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Stock structure & distribution

There are two biologically distinct stocks of Gemfish in Australia, Eastern and Western biological stocks, separated by a boundary at the western edge of Bass Strait (Colgan and Paxton, 1997; Emery et al., 2021). Studies suggest that there are no genetic differences between Gemfish in eastern Australia and New Zealand (Colgan and Paxton, 1997). For the purposes of management and assessment, the eastern Australian population is treated as a single biological stock, independent of the New Zealand population.

The eastern stock is distributed from Cape Moreton in southern Queensland to waters off Tasmania. Gemfish are mesopelagic and inhabit deeper continental shelf and upper slope waters from 100 – 700 m but are concentrated in 350 – 450 m depths on the continental slope (AFMA, 2015; Little and Rowling, 2011; Emery et al., 2021; Patterson et al., 2021).

Scope of this assessment

Assessment of the status of the stock of Gemfish (*Rexea solandri*) that is fished by commercial and recreational fishers in New South Wales (NSW) is based on the modelling and assessment done for the eastern stock of this species by the Commonwealth of Australia. The primary mechanism for controlling the harvest of the eastern stock of Gemfish in the Commonwealth's Southern and Eastern Scalefish and Shark Fishery (SESSF) is through the allocation of an Annual Total Allowable Catch (TAC). Determination of annual TACs for the Commonwealth SESSF is based on the SESSF Harvest Strategy Framework (HSF) (AFMA, 2017) that is consistent with the Commonwealth Fisheries Harvest Strategy Policy (HSP) (DAWR, 2018a, 2018b).

Status of the Gemfish (Eastern) stock is assessed relative to limit and target reference points prescribed in the HSF/HSP. The Tier-1 assessment uses a statistical catch-at-length, catch-at-age model. The model provides retrospective and prospective estimates of biomass (the latter for alternative TACs) and thereby generates, through harvest control rules, a Recommended Biological Catch (RBC). The intention of this process is to move the stock biomass toward and maintain it around the target reference point. Because the Eastern Gemfish spawning biomass is currently below its limit reference point, the stock is currently managed under the Eastern Gemfish Stock Rebuilding Strategy 2015 (AFMA, 2015).

This summary of stock status provides a summary of the most recent Commonwealth stock assessment for Gemfish (eastern). Current determinations of status based on criteria specified by

the Commonwealth and also those used for the Status of Australian Fish Stocks (SAFS) are provided.

Appendix 1 provides a summary of the rationale by which the Commonwealth assessment for Gemfish (Eastern) is considered to be relevant and valid for determining the status of the Gemfish stock fished within NSW jurisdiction.

Appendix 2 provides a summary of recent catches of Gemfish by the NSW fisheries / share-classes that catch them and the subset of these fisheries for which (i) a NSW TAC is to be determined (*Trap and Line – Line East*) and (ii) the trawl fisheries for which a daily catch limit and possession limit applies. Additional information that may inform determination of the NSW TAC is provided here.

Biology

Females mature at 4 – 6 years of age at 60 – 75 cm fork length (FL) and can live to approx. 17 years of age, attaining a maximum length of 116 cm and weight of 13 kg. Males mature at 3 – 5 years of age at 50 – 70 cm FL, are shorter-lived than females with a maximum age of about 12 years and attain a maximum length of about 106 cm and weight 8 kg. Mature fish migrate northwards along the continental slope to spawn of central and northern NSW in early – mid August (AFMA, 2015; Little and Rowling, 2011; Emery et al., 2021; Patterson et al., 2021).

FISHERY STATISTICS

Catch information

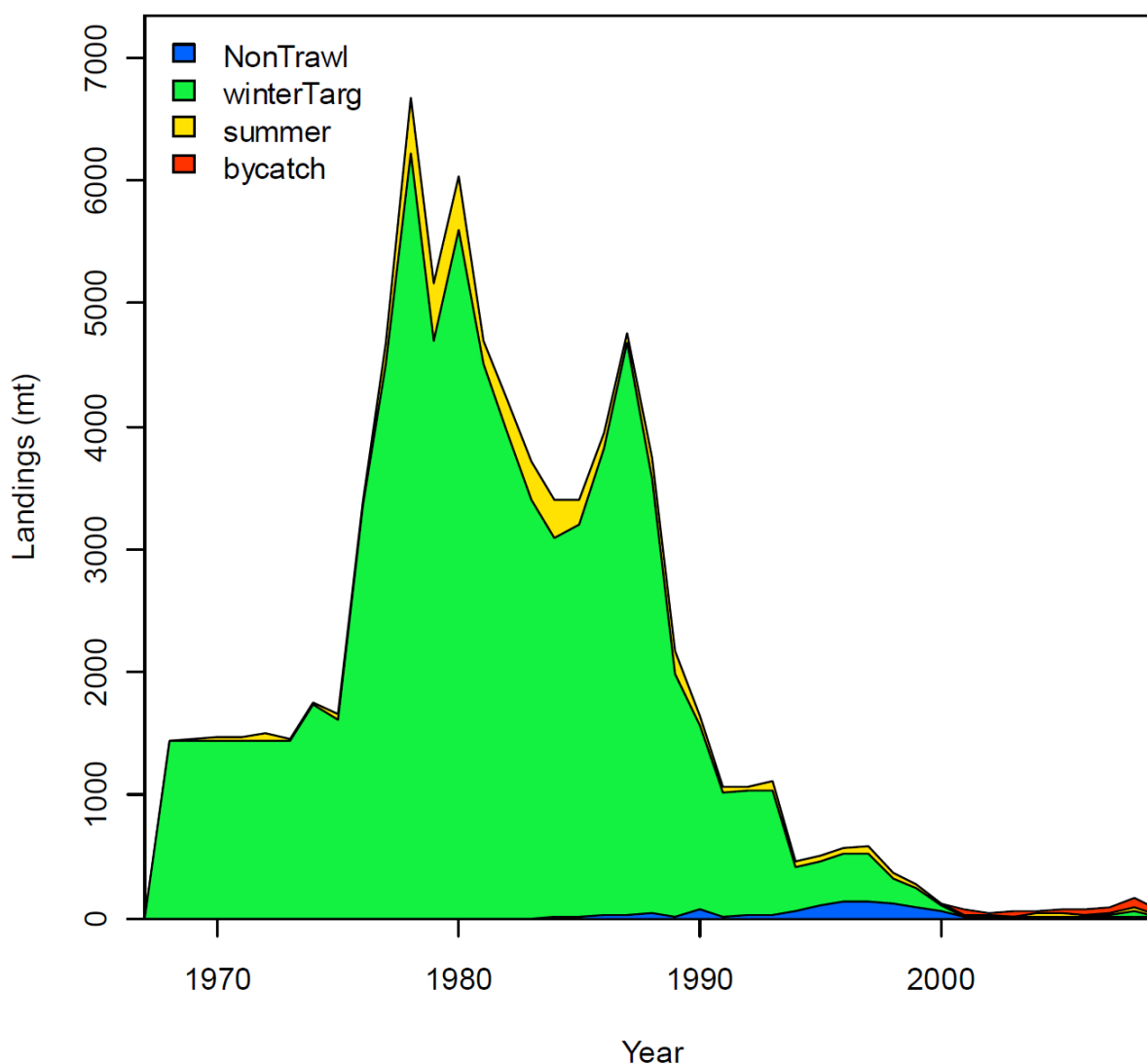
Commercial

Commercial landed catches of Gemfish that were included in the 2010 assessment (Little and Rowling, 2011) between 1968 and 2009 are shown in Figure 1. These data represent catches from the 4 fleets that were represented in the assessment model (winter targeted, summer non-targeted, non-trawl, bycatch). Landed catches since 2010 have been in the range 25.9 – 112.8 t and are documented in Althaus et al. (2020) and Emery et al. (2021). The landed catch of 112.8 t in 2010 exceeded the 100 t incidental catch TAC. Landed catches since 2010 have been below this level and in the range 25.9 – 86.3 t. Landed catches in the last 2 years were 72.0 t in 2019 and 62.8 t in 2020. It is, however, important to note that estimated total catches (landings plus estimated discards) during the period 2010-20 have been in the range 48.7 – 304.0 t.

Information about rates of discarding were available from the Integrated Scientific Monitoring Program (ISMP) between 1993 and 2007 and included in the 2010 assessment. Observed annual discard rates were close to 0 for the non-trawl fleet and within the range 0 – 0.5 for the 3 components of the fish trawl fleet considered in the model (Little and Rowling, 2011).

Subsequently, since 2010, discard fractions have remained high (26.4 – 67.3%) with annual quantities discarded in the range 22.8 – 191.2 t (Althaus et al., 2020).

Figure 1 Annual landed catch (t) of Eastern Gemfish by fleet from 1968-2009. Green: targeted winter spawning run fleet; Yellow: non-spawning season trawl fleet; Blue: non-trawl fleet; Red: winter bycatch trawl. This figure reprinted from Fig. 1 in Little and Rowling (2011).



Recreational & Charter boat

The Commonwealth assessment does not, at present, include estimates of Gemfish catches by the recreational sector. Neither does the process by which the Commonwealth TAC is calculated from the RBC account for recreational catch. Surveys of the catches in NSW by NSW-resident recreational fishers during 2013/14 and by 1-3 year licence holders in 2017/18 did not detect any catches of Gemfish (West et al, 2015; Murphy et al., 2020). There is, however, anecdotal evidence, including photographs and reports on social media websites, indicating that Gemfish are targeted and captured by a small subset of recreational anglers using specialist gear. The interpretation of the survey results and the evidence from social media is that catches of Gemfish by recreational fishers in NSW are negligible, relative to the magnitude of commercial catches.

Indigenous

Neither the Commonwealth assessment or the process for determining the Commonwealth TAC from RBC includes estimates of Gemfish catches by the Aboriginal sector. Given the depths inhabited by Gemfish, this species would not have been a traditional target species for Aboriginal fishers. As for the recreational catch, any catches by the Aboriginal fishers in recent history are negligible, relative to the magnitude of commercial catches.

Illegal, Unregulated and Unreported

Unaccounted.

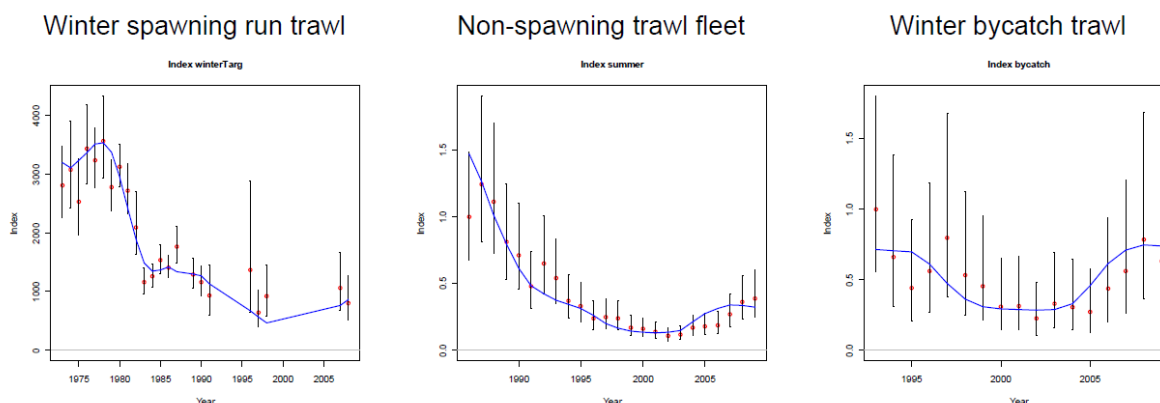
Fishing effort information

Fishing effort used in calculation of CPUE within Commonwealth assessment.

Catch Rate information

Indices of catch rate (standardised CPUE) used in the Commonwealth assessment were available for three “fleets”: the winter targeted spawning run fleet; the non-spawning-season trawl fleet; and the winter spawning season bycatch trawl fleet (Little and Rowling, 2011). These standardisations derive from analyses done by Punt et al. (2000), Little and Rowling (2008) and Haddon (2009). These time-series show substantial declines between the 1970s and late 1990s (Fig. 2).

Figure 2 Standardised observed catch rates (circles) and model-estimated (lines) catch rates vs year, for each of 3 fleets, as used in the 2009 assessment. Error bars indicate approximate 95% confidence intervals for the data. This figure reprinted from Fig. 3 in Little and Rowling (2011).



Since 2009, standardised catch rates for both the “winter spawning” and “non-spawning” fleets declined but then increased during the last 4 years since 2017 (Sporcic, 2020). This recent increase is consistent with industry reports of higher catch rates in 2019 and 2020. However, note

that these catch rates are essentially based on bycatches so may not necessarily be indicative of abundance.

STOCK ASSESSMENT

Stock Assessment Methodology

Year of most recent assessment:

2010 (most recent “full” tier-1 assessment)

Annual reviews of Eastern Gemfish stock rebuilding strategy since.

Assessment method:

Commonwealth Tier 1 assessment using a 2-sex, multiple fleet, statistical age- and length-structured model implemented in the software package *Stock Synthesis*, SS3

Main data inputs:

Commercial landings for each of 4 “fleets”: targeted winter spawning run fleet; non-spawning season trawl fleet, non-trawl fleet; winter bycatch trawl fleet

Discarded commercial catch estimates sourced from the ISMP (1993 – 2007)

Commercial catch rates (CPUE): standardised CPUE indices for 3 fleets: targeted winter spawning run fleet; non-spawning season trawl fleet, winter bycatch trawl fleet

Proportional age-composition data based on otolith ageing (1980 – 1992)

Conditional age-at-length data (by fleet) based on otolith ageing (1993-2000, 2007, 2008)

Length composition data: sex-aggregated length-frequencies for the non-trawl fleet (1993-2008); sex-aggregated length-frequencies (1975-2000) and sex-specific length frequencies (1983-1999) for the winter targeted spawning run fleet; sex-aggregated length-frequencies for the summer trawl fleet (1975-2008); sex-aggregated length-frequencies for the winter bycatch trawl fleet (2000-2008). Onboard data from the ISMP used to calculate length-frequencies of discards for winter targeted, winter bycatch and summer trawl fleets

Key model structure & assumptions:

2-sex, multiple fleet, statistical age- and length-structured model implemented in the package SS3

4 fleets modelled (3 fish trawl and 1 non-trawl fleet)

Eastern Gemfish biological stock is a single stock

2-sex, multiple fleet, statistical age- and length-structured model implemented in the package SS3

4 fleets modelled (3 fish trawl and 1 non-trawl fleet)

Eastern Gemfish biological stock is a single stock

Stock assumed to be unexploited at start of 1968 (i.e. catches prior to this minimal)

Stock Status Summary – 2021/22



NSW Stock Status Summary – Gemfish (*Rexea solandri*)

As model is conditioned on landed catch, it is assumed that:

- (i) Commercial catches reported for each fleet and from each jurisdiction are accurate
- (ii) Catches from other sectors (recreational and Aboriginal) are insignificant (relative to commercial catches)

Selectivity varies among fleets and is time-invariant except that the selectivity for the winter spawning run fleet is assumed to have changed when the TAC was set to 0

Selectivity ogives modelled as logistic functions of length with 2 parameters estimated within the assessment model

Retention (versus discard) modelled as a logistic function of length with inflection and slope parameters estimated for the fleets for which discard information was available

Natural mortality, M , assumed age- and time-invariant and equal to 0.38 yr^{-1} for females and 0.56 yr^{-1} for males for base-case scenario of model

Beverton-Holt stock-recruitment relationship parameterised by (i) pre-exploitation recruitment (R_0) and steepness (h)

An age plus-group modelled at age 25; growth assumed to be sex-dependent and time-invariant; mean size-at-age time invariant

Distribution of size-at-age determined from fitting the growth curve within the assessment using age-at-length data (for 2 genders)

Max length 107 cm FL for females, 97 cm FL for males

Length-weight parameters: $a = 1.43 \times 10^{-6}$, $b = 3.39$

50% maturity at 70 cm FL

All sample sizes of length-frequency data greater than 200 were set to 200 to control the relative influence of this data compared to other data sources during model fitting.

Sources of uncertainty evaluated:

Evaluation of base-case model fits (estimated) to observed (input data) for:

- indices of abundance time-series (by fleet)
- discard fraction time-series (by fleet)
- length compositions of retained catch (by fleet)
- length compositions of discarded catch (by fleet)
- age compositions of retained catch (by Fleet)
- age compositions of discarded catch (by fleet)

Sensitivity scenarios based on alternative assumptions to those used in the base-case included:

- fixed growth parameters
- estimate M
- use alternative catch series (catch series A from Punt et al, 2001)
- stock recruitment steepness set to 0.75
- alternative emphasis on CPUE (x 0.5, x 2)

Stock Status Summary – 2021/22



NSW Stock Status Summary – Gemfish (*Rexea solandri*)

- alternative emphasis on length-compositions (x 0.5, x 2)
- alternative emphasis on age-compositions (x 0.5, x 2)

Status Indicators - Limit & Target Reference Levels

Biomass indicator or proxy	Depletion of spawning biomass (model estimated)
Biomass Limit Reference Point	B ₂₀ (20% of pre-exploitation spawning biomass)
Biomass Target Reference Point	B ₄₈ (48% of pre-exploitation spawning biomass)
Fishing mortality indicator or proxy	Fishing mortality (model estimated)
Fishing mortality Limit Reference Point	N/A
Fishing Mortality Target Reference Point	F ₄₈ (Fishing mortality rate that achieves B ₄₈)

Stock Assessment Results

The most recent tier-1 stock assessment for Eastern Gemfish was done in 2010, based on data up to 2009 (Little and Rowling, 2011; Little, 2012). Historically high catches of Gemfish through the 1970s and 1980s (peaking in 1978 at more than 6,000 t) substantially reduced the biomass of Eastern Gemfish by the 1990s. The biological stock has remained at a depressed level, with limited recruitment since this time (Fig. 3). The 2010 assessment estimated that biomass was only 15.6 % of the unfished (1968) level (Little and Rowling, 2011). Based on (i) this estimate, which is less than the limit reference point (20% depletion) and (ii) no evidence of recovery in recent years, the stock status is determined to be **overfished** (Patterson et al., 2021). The Eastern Gemfish stock has been classified as overfished since 1992.

An analysis of spawning potential ratio indicated high fishing mortality rates on Eastern Gemfish until the late-1990s, but much lower rates since 2002 (Little, 2012). Because fishing mortality rates had substantially decreased, assessment model projections, assuming an annual incidental catch of 100 t, indicated that the stock should reach 20 per cent of unfished biomass (the limit reference point) by 2025 (Fig. 3). This rebuilding projection was, however, based on future recruitments determined from the stock recruitment relationship and total removals being limited to the incidental catch allowance. A preliminary tier-1 update to the 2010 assessment estimated that spawning biomass in 2015 had decreased to 8.3% of the unfished (1968) level, likely due to lack of recruitment (AFMA, 2016). The first objective of the Stock Rebuilding Strategy is to rebuild the Eastern Gemfish stock to 20% of the unfished spawning stock biomass within a “biologically reasonable timeframe”, this being approximately 19 years (one mean generation time plus 10 years) (AFMA, 2015). Due to conflicting signals from (i) the 2010 assessment projections and (ii) the preliminary update of the assessment (AFMA 2016), it is unclear whether the stock will recover within the target timeframe. Accordingly, the stock is classified as **uncertain if subject to overfishing** (Patterson et al., 2021).

Stock Status Summary – 2021/22

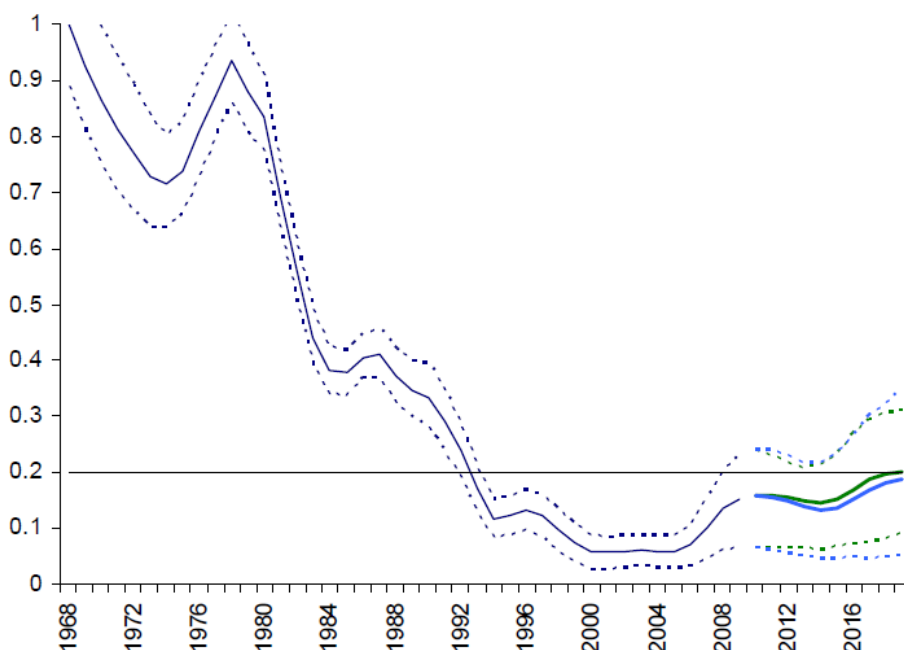


NSW Stock Status Summary – Gemfish (*Rexea solandri*)

The Commonwealth TAC for 2021-22 remains at 100 t (AFMA, 2021) and is likely to remain at this level in 2022-23. This is an allowance for incidental catch because the RBC under the HSP is 0 and the HSP and Stock Rebuilding Strategy provide for zero targeted catch.

Stock status under SAFS criteria is **depleted** (Emery et al., 2021).

Figure 3 Time-trajectories of female spawning biomass depletion under 0 t TAC and 100 t TAC (0.05 and 0.95 percentiles). This figure reprinted from Fig. 5 in Little and Rowling (2011).



Stock Assessment Result Summary

Biomass status in relation to Limit	At start of 2010: B = 15.6% << B ₂₀ Since 2010 and current: << B ₂₀
Biomass status in relation to Target	At start of 2010: B = 15.6% << B ₄₈ Since 2010 and current: << B ₄₈
Fishing mortality in relation to Limit	N/A
Fishing mortality in relation to Target	Uncertain
Current SAFS stock status	Depleted
Current Commonwealth stock status	Overfished & Uncertain of subject to overfishing

Fishery interactions

There is interaction between fisheries managed under NSW and Commonwealth jurisdiction. Fish trawling at latitudes north of Barrenjoey Pt (NSW) is under NSW jurisdiction and trawling (in outer-shelf continental slope depths) to the south, fall under Commonwealth jurisdiction. Under OCS arrangements, commercial line-fishing methods are under NSW jurisdiction in waters off NSW.

During the 1970s, 1980s and early 1990s, the substantial catches of Gemfish came from targeting spawning aggregations during the winter months. This targeted fishery no longer exists due to the depleted state of the stock and consequent management restrictions. Catches of Gemfish in recent years represent bycatches from trawling and line-fishing for species such as Blue-eye trevalla, Pink Ling and Bigeye ocean perch that inhabit similar depths.

Qualifying Comments

The timeframe for rebuilding biomass to the limit reference point of 20% B₀ for two scenarios of annual landings was considered in the 2010 assessment. Assuming a landed catch of 100 t per annum and the average recruitment predicted by the stock-recruitment relationship, it was projected that the spawning stock would rebuild to 20% B₀ by 2025. Evidence of any significant recovery of biomass is lacking but SERAG has supported an update of the tier-1 assessment in 2021 using updated annual catches, available biological data and fishery-dependent indices of abundance from the bycatch fisheries (noting the absence of indices of abundance from the winter fishery that used to target spawning aggregations).

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Appendix 1

Reliability and Relevance of the Commonwealth Assessment to assessment of stock status in NSW

As a “Tier 1” Commonwealth assessment, this assessment is classed as being of high quality. It is based on a statistical catch-at-age / catch-at-length model incorporating multiple fleets and is calibrated with multiple time-series of data including indices of abundance, estimates of discarding, and size- and age-distributions. The model is conditioned on catch data for commercial fisheries sourced from each of the relevant jurisdictions.

Because the stock of Eastern Gemfish fished in Commonwealth and NSW jurisdictions represents a single biological stock, it is appropriate that NSW use the Commonwealth assessment as the basis for determining stock status in NSW.

The commercial landings data used in the model include landings data from NSW.

Based on the assumption that catches of Gemfish by the recreational and Aboriginal sectors are negligible compared to the annual commercial catch, the omission of recreational and Aboriginal catch from the model and Commonwealth assessment has little effect on the assessment outcome that the Eastern Gemfish stock is depleted / overfished.

An updated Commonwealth assessment scheduled for 2022, based on the tier-1 stock synthesis model developed for the 2010 assessment, will provide contemporary estimates of stock status and rebuilding timeframes for the Gemfish stock.

Appendix 2

NSW catch statistics and additional information relevant to TAC setting in NSW

1. The Eastern Gemfish stock is depleted /overfished and the Commonwealth SESSF RBC is 0. A bycatch TAC of 100 t is in place to allow for the incidental (non-targeted) catch of Eastern Gemfish in the SESSF.
2. The need to minimise fishing mortality on Eastern Gemfish in fisheries under NSW jurisdiction is of fundamental importance. In determining a reasonable NSW TAC, a logic equivalent to that used by the Commonwealth for the SESSF would be to set a TAC that (i) allowed for incidental (non-targeted) catch and (ii) did not facilitate targeting.
3. Catches of Gemfish in the NSW trawl fisheries which are not subject to a Gemfish TAC, but for which a 50 kg daily catch and possession limit applies, have been a minor component of the NSW commercial catch, representing less than 1 t and less than 10% of the annual commercial catch since 2010-11 (Table 1, Fig. 4, Table 2). The daily catch and possession limit effectively limits the incentive to target Gemfish in these fisheries.
4. Because NSW Gemfish shares and quota can be traded among fishing businesses within the *Line East* component of the *Trap and Line* fishery, it is theoretically possible that Gemfish quota could become concentrated in a small number of businesses (theoretically even a single business). If this was to occur, then targeting of Gemfish could be worthwhile for the fisher(s) holding the quota and this would be at odds with the purpose of a TAC allocated to facilitate incidental catch. Moreover, fishers who traded their small quotas or share-holdings of Gemfish would be discarding any incidental captures they made, adding to fishing mortality. The risk of this occurring requires consideration, as do management options that would mitigate such risk. Note, however, that there is no evidence that this has occurred during the last 3 years.
5. The logic in determining a TAC for Gemfish taken by the *Line East* component of the *Trap and Line* fishery is also in the domain of a “resource sharing policy” between NSW and the Commonwealth. In contrast to other shared species, for which the issue concerns sharing a substantial RBC, the issue here is sharing a small “incidental catch allowance” that is deemed to be compatible with stock recovery.
6. Statistics describing landings of Gemfish from NSW commercial fisheries during recent years (2009-10 to 2020-21) may inform determination of a NSW TAC that is consistent with the development an inter-jurisdictional resource sharing policy (Table 1, Fig. 4 and Table 2). Note that the majority (> 90%) of annual NSW catches of Gemfish was taken by the *Trap and Line – Line East* fishery (between 2009-10 and 2020-21). Annual catches in the *Line East* fishery have declined during this 12-year period, from 19.333 t in 2009-10 to 0.997 t in 2020-21. Annual catches have been less than 4 t in each of the last 6 years.

Stock Status Summary – 2021/22



NSW Stock Status Summary – Gemfish (*Rexea solandri*)

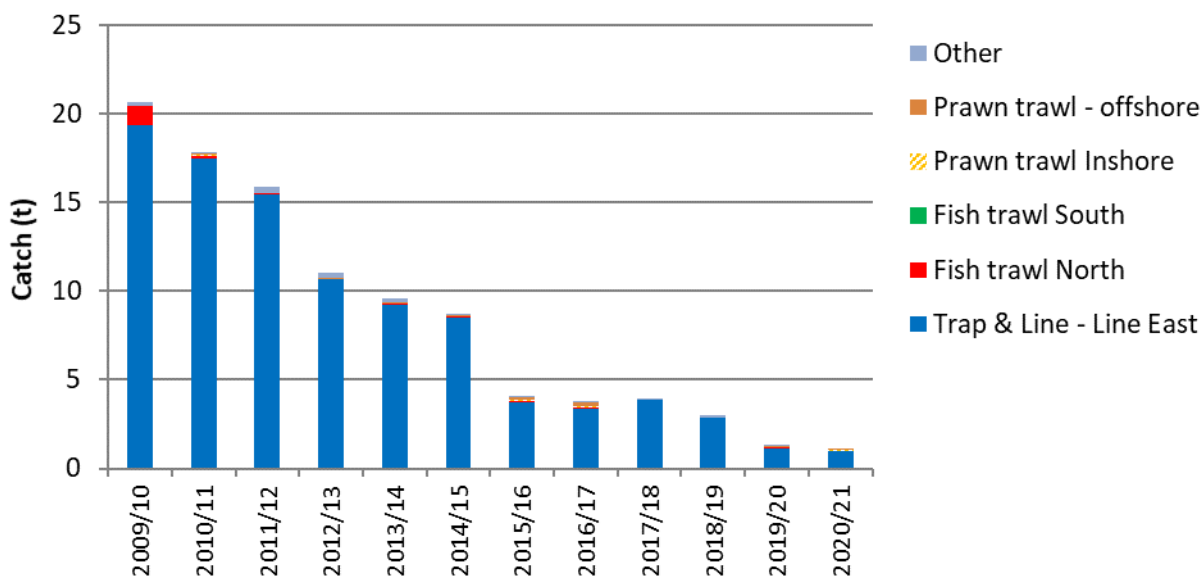
Table 1 Annual catches of Gemfish by NSW commercial fisheries, by fishery/share-class, 2009-10 to 2020-21.

Blue column (Trap & Line – Line East) indicates the share class for which a TAC applies.

Grey columns indicate share-classes for which a 50 kg daily catch and possession limit applies.

Year	Fishery / Share-class							Total (t)
	Fish Trawl North (t)	Fish Trawl South (t)	Prawn Trawl Inshore (t)	Prawn Trawl Offshore (t)	Prawn Trawl Deep water (t)	Trap & Line Line East (t)	Other (t)	
2009/10	1.107	0.000	0.007	0.011	0.000	19.333	0.161	20.618
2010/11	0.127	0.029	0.037	0.099	0.000	17.468	0.030	17.789
2011/12	0.089	0.000	0.011	0.017	0.000	15.424	0.370	15.909
2012/13	0.039	0.000	0.010	0.029	0.000	10.652	0.335	11.063
2013/14	0.060	0.000	0.018	0.043	0.000	9.219	0.255	9.594
2014/15	0.068	0.000	0.000	0.015	0.000	8.538	0.040	8.662
2015/16	0.073	0.000	0.016	0.202	0.000	3.762	0.031	4.083
2016/17	0.074	0.000	0.073	0.169	0.000	3.382	0.055	3.752
2017/18	0.000	0.000	0.000	0.036	0.000	3.875	0.045	3.955
2018/19	0.003	0.000	0.002	0.057	0.037	2.830	0.086	3.015
2019/20	0.063	0.000	0.000	0.066	0.000	1.146	0.053	1.328
2020/21	0.002	0.000	0.033	0.024	0.000	0.997	0.000	1.055

Figure 4 Reported landings of Gemfish in NSW commercial fisheries / share-classes, 2009-10 to 2020-21.



Stock Status Summary – 2021/22



NSW Stock Status Summary – Gemfish (*Rexea solandri*)

Table 2 Summary statistics based on recent annual reported commercial catches (2009-10 to 2020-21) of Gemfish which may assist with NSW TAC determination.

Blue column indicates the fishery/share-class (Trap & Line – Line East) for which a NSW TAC applies

Grey column indicates the fisheries/share-classes (Fish Trawl North, Prawn trawl Inshore, Prawn Trawl Offshore, Prawn Trawl Deepwater) for which a 50 kg daily catch and possession limit applies.

Year	TAC managed fishery Trap & Line Line East (Catch, t)	50 kg Daily catch & Possession Limit Fisheries (Catch, t)	Fish Trawl south (Catch, t)	Other (Catch, t)
2009/10	19.333	1.125	0.000	0.161
2010/11	17.468	0.263	0.029	0.030
2011/12	15.424	0.116	0.000	0.370
2012/13	10.652	0.077	0.000	0.335
2013/14	9.219	0.121	0.000	0.255
2014/15	8.538	0.083	0.000	0.040
2015/16	3.762	0.291	0.000	0.031
2016/17	3.382	0.315	0.000	0.055
2017/18	3.875	0.036	0.000	0.045
2018/19	2.830	0.099	0.000	0.086
2019/20	1.146	0.129	0.000	0.053
2020/21	0.997	0.058	0.000	0.000
Min:	0.997			
Max:	19.333			
Median:	6.206			
Mean:	8.052			