Stock status summary - Gemfish - 2020

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).

The information in this section 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 the determination of a NSW TAC is provided here.

Assessment authors and year

Liggins, G. 2020. Stock status summary – Gemfish - 2020. NSW Department of Primary Industries. Fisheries NSW, Mosman. 15 pp.

Biology and stock structure

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; Moore et al., 2018). 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; Moore et al., 2018; Patterson et al., 2019).

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; Moore et al., 2018; Patterson et al., 2019).

Stock Status and rationale

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. 1). 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 **recruitment overfished** (Patterson et al., 2019). 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. 1). 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. Note also that recent catch history includes years during which the incidental catch allowance was exceeded by reported catch plus discards (e.g. 2010, 2011, 2012 and 2013; Burch et al., 2019). Accordingly, the stock is classified as **uncertain if subject to overfishing** (Patterson et al., 2019).

The Commonwealth TAC for 2019-20 remains at 100 t (AFMA, 2018). 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** (Moore et al., 2018).

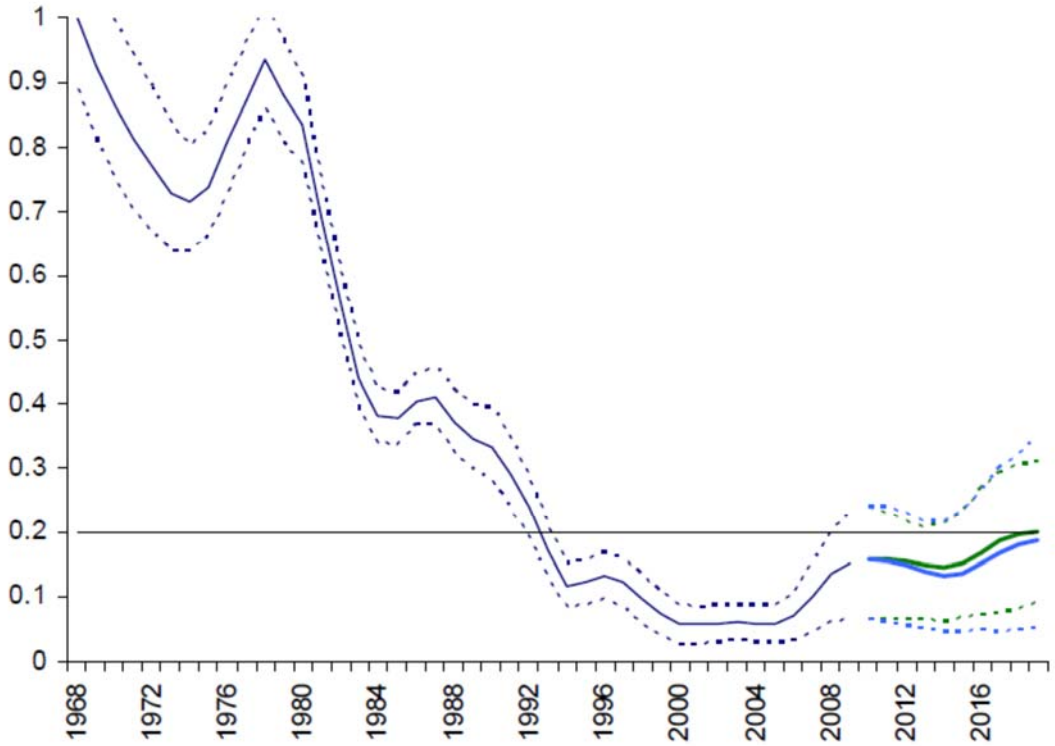

Figure 1 Time-trajectories of female spawning biomass depletion under 0 t TAC and 100 t TAC (0.05 and 0.95 percentiles). This figure reprinted from Fig. 5 in Little and Rowling (2011).

Fishery statistics summary

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 2. 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 – 112.7 t and are documented in Burch et al. (2019) and Moore et al. (2018). The landed catch of 112.7 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 – 86.1 t. It is, however, important to note that estimated total catches (landings plus estimated discards) exceeded the 100 t allowance/target each year during the period 2010-13 (303.7 t in 2010, 193.9 t in 2011, 112.7 t in 2012 and 209.8 t in 2013). Since 2014, annual total catches have been in the range 36.3 – 93.4 t.

Recreational / Indigenous

The Commonwealth assessment does not, at present, include estimates of Gemfish catches by the recreational or Aboriginal fishing sectors.

Charter Boat

The Commonwealth assessment does not, at present, include estimates of Gemfish catches by the Charter boat sector.

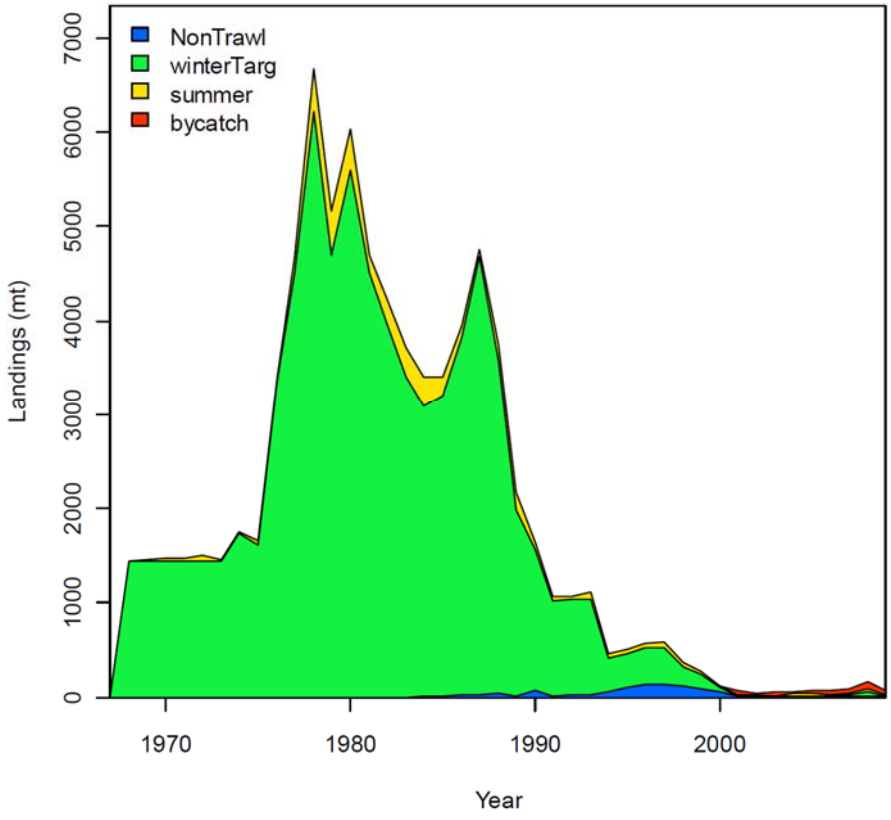

Figure 2 Annual landed catch (t) of Eastern Gemfish by fleet from 1968-2009. Green: targeted winter spawning run fleet; Yellow: non-spawning season trawl fleet; Blue: non-trawl fleet; Red: winter bycatch trawl. This figure reprinted from Fig. 1 in Little and Rowling (2011).

Discards

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, and discard fractions have remained high (28.7 - 62.9%) with annual quantities discarded in the range 10.4 – 191.1 t (Burch et al., 2019).

Illegal, Unregulated and Unreported (IUU)

The Commonwealth assessment does not, at present, include any allowance for an IUU component of fishing mortality.

Other jurisdictions

The Commonwealth assessment model includes landed commercial catch data from State jurisdictions (principally NSW). Discard fractions for the non-trawl fleet (principally drop-lining in NSW) are also included.

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. 3).

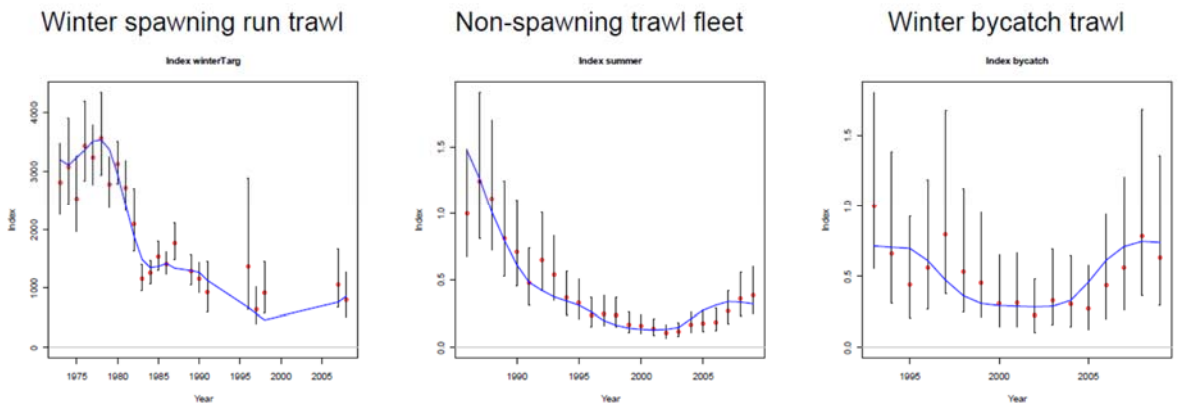

Figure 3 Standardised observed catch rates (circles) and model-estimated (lines) catch rates vs year, for each of 3 fleets, as used in the 2009 assessment. Error bars indicate approximate 95% confidence inetrvals for the data. This figure reprinted from Fig. 3 in Little and Rowling (2011).

Standardised catch rates for both the "winter spawning" and "non-spawning" fleets have declined since 2009 (AFMA, 2019). However, note that these catch rates are essentially based on bycatches so may not necessarily be indicative of abundance. Nevertheless, they provide no evidence of stock recovery.

Stock Assessment Summary

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
Main data inputs (rank)	Model conditioned on landed catch (*1) Multi-stage procedure used to tune model to: - observed catch rates (*1) - discard fractions (*1) - length compositions & age compositions (*1)
Key model structure and 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

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

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

*1 – High Quality: data have been subjected to documented quality assurance and peer review processes, are considered representative and robust and provide a high level of confidence to support fisheries management decisions.

2 – Medium quality: data have been subjected to some internal quality assurance processes, have some documented limitations, but are still considered sufficiently accurate and informative to be useful to inform management decisions with some caveats.

3 – Low quality: data have been subjected to limited or no quality assurance processes, may be compromised by unknown or documented limitations that have not been fully explored, but are considered the best available information and require a high level of precaution to be exercised when interpreted to inform management decisions.

Status Indicators, Limit, Inflection and Target Reference Levels	
Biomass indicator or proxy	Depletion of spawning biomass (model estimated)
Biomass LIMIT reference level	B_{20} (20% of pre-exploitation spawning biomass)
Biomass Harvest Control Rule (HCR) INFLECTION ref. level ("BREAKPOINT")	B_{35} (35% of pre-exploitation spawning biomass)
Biomass TARGET reference level	B_{48} (48% of pre-exploitation spawning biomass)
Fishing mortality indicator or proxy	Fishing mortality (model estimated)
Fishing mortality LIMIT reference level	NA

Status Indicators, Limit, Inflection and Target Reference Levels	
Fishing mortality TARGET reference level	F_{48} (Fishing mortality rate that achieves B_{48})

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 INFLECTION (BREAKPOINT)	At start of 2010: B = 15.6% **<< B_{35}** Since 2010 and current: << **B_{35}**
Biomass status in relation to TARGET	At start of 2010: B = 15.6% **<< B_{48}** Since 2010 and current: **<< B_{48}**
Commonwealth 2019 stock status	**Recruitment overfished** **Uncertain if subject to overfishing**
SAFS 2018 stock status	**Depleted**

APPENDIX 1 – Reliability and Relevance of the Commonwealth Assessment to assessment of stock status in NSW

1. 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.

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

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

4. The Commonwealth assessment does not consider recreational or Aboriginal catch. The model is conditioned on commercial catch data alone. Neither does the process by which the Commonwealth TAC is calculated from the RBC account for recreational/Aboriginal catch. A survey of the catches in NSW by NSW-resident recreational fishers during 2013/14 did not detect any catches of Gemfish (West et al, 2015). The interpretation of this result is that catches of Gemfish by recreational fishers in NSW are negligible, relative to the magnitude of commercial catches. Thus, 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.

APPENDIX 2 – 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 of 50 kg 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 limit 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.

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 – 2018/19) 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 2018-19). Annual catches in the Line East fishery have declined during this 10-year period, from 19.333 t in 2009-10 to 2.830 t in 2018-19. Annual catches have been less than 4 t in each of the last 4 years.

7. The NSW TAC set for Gemfish for the 2019-20 fishing period (1 May 2019 – 30 April 2020) is 7.1 t. As at 29 Feb 2020, with 2 months remaining in the fishing season, less than 1 t of Gemfish has been taken against this TAC.

Table 1 **Annual catches of Gemfish by NSW commercial fisheries, by fishery/share-class, 2009/10 – 2018/19.**

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.

	Fishery / Share-class							
Year	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)	Total (t)
2009/10	1.008	0.099	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	10.702	0.285	**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	0.029	**8.651**
2015/16	0.073	0.000	0.016	0.202	0.000	3.773	0.047	**4.110**
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	0.050	**3.960**
2018/19	0.040	0.000	0.002	0.057	0.000	2.830	0.086	**3.015**

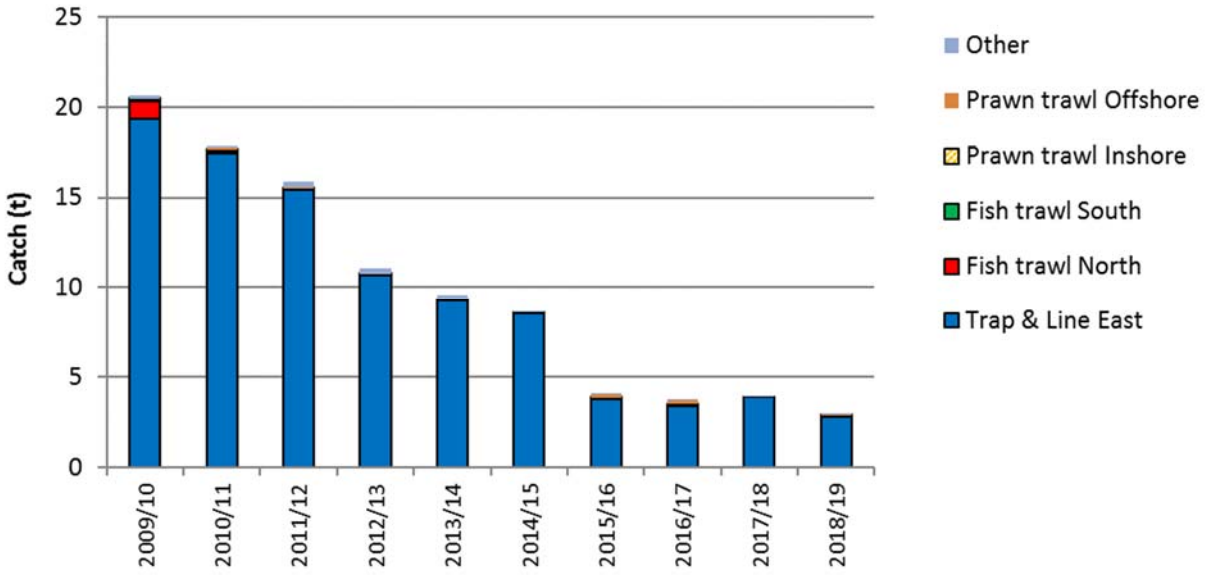

Figure 4 **Reported landings of Gemfish in NSW commercial fisheries / share-classes, 2009/10 – 2018/19.**

Table 2 **Summary statistics based on recent annual reported commercial catches (2009/10 – 2018/19) 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	1.026	0.099	0.161
2010/11	17.468	0.263	0.029	0.030
2011/12	15.424	0.116	0.000	0.370
2012/13	10.702	0.077	0.000	0.285
2013/14	9.219	0.121	0.000	0.255
2014/15	8.538	0.083	0.000	0.029
2015/16	3.773	0.291	0.000	0.047
2016/17	3.382	0.315	0.000	0.055
2017/18	3.875	0.036	0.000	0.050
2018/19	2.830	0.099	0.000	0.086
Min:	2.830			
Max:	19.333			
Median:	8.878			
Mean:	9.454			

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