Stock assessment of Saddletail Snapper (*Lutjanus malabaricus*) in the Northern Territory Demersal and Timor Reef Fisheries.

INTRODUCTION

The Northern Territory Offshore Snapper Fisheries, comprising the Demersal Fishery and the Timor Reef Fishery (TRF), operate in waters 15 nautical miles from the coastal baseline to the outer limit of the Australian Fishing Zone (Figure 1). In February 2012, the then separately managed Finfish Trawl Fishery was redefined and incorporated into the Demersal Fishery, resulting in two zones in which finfish trawl gear is permitted within this fishery. At the same time a new management regime based on Individual Transferrable Quotas (ITQ) was introduced in the Demersal Fishery. This followed the introduction of ITQ in the TRF a year earlier.

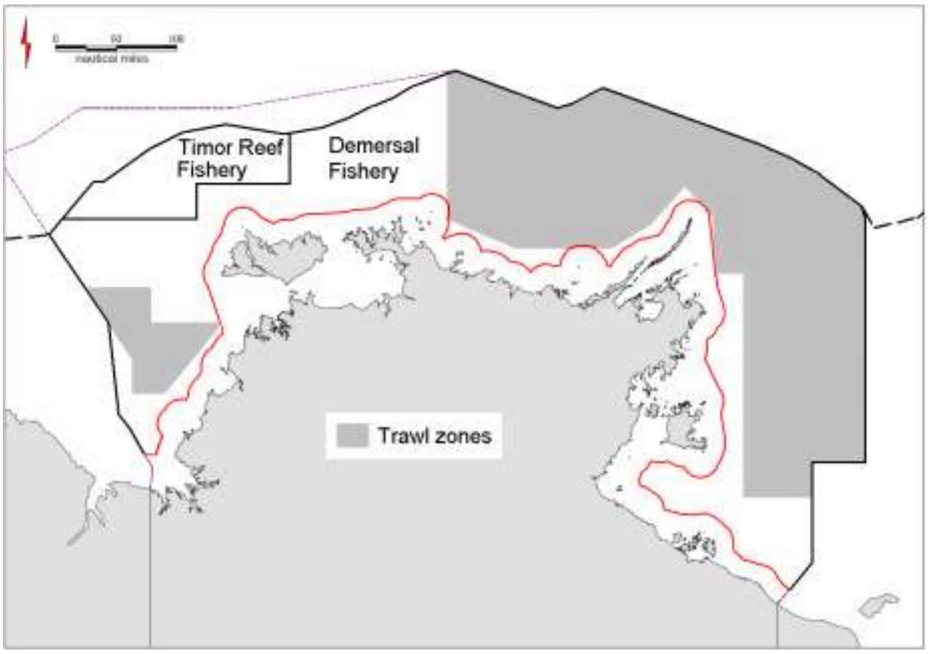

Figure 1. Offshore snapper fishing areas.

With the introduction of ITQ management, harvests were expected to increase rapidly to reach the Total Allowable Commercial Catches (TACCs). The initial TACCs for all harvested species were based on estimates of sustainable yield generated from 20 year old survey data. Recently, the harvest of Goldband Snapper by the TRF was assessed at a workshop in 2011 using Stock Reduction Analysis (SRA). This modelling approach works well for data-poor fisheries and was used in a previous assessment in 1996 (Grubert et al. 2013; Ramm, 1997).

Following that workshop, Industry requested a similar assessment of red snapper stocks. The current assessment was conducted on Saddletail Snapper and the results will be used as an indicator for the red snapper group as a whole. This report presents the result of that assessment.

Overview of the fishery

Foreign fishing

The Arafura and Timor Seas, to the north of Australia, have been fished at varying intensities for more than 50 years. Commercial operations began with Japanese stern trawlers operating from the late 1950s to the early 1960s, when these were international waters. During the 1970s, Taiwanese pair trawlers fished northern Australian waters intensively and, after the ratification of the Australian Fishing Zone in 1979, Thai and Chinese vessels joined the existing fleet and continued to fish under Australian licence agreements until 1990. Total catches from the Arafura Sea during that time peaked at around 10 000 tonnes in 1983.

Domestic fishing

Due to increasing interest by domestic operators and concerns about overfishing of snapper resources in the region, access by foreign fleets ceased in 1991. In 1995, management of the fisheries in waters adjacent to the NT passed to the NT Fisheries Joint Authority and in that year a single domestic trawl vessel began to fish to the east of the TRF in the Arafura Sea and, until 1999, most fishing occurred either in the TRF (targeting Goldband Snapper) or the Finfish Trawl Fishery (targeting “red snappers”).

Harvest of Saddletail Snapper by the Indigenous and recreational sectors is low, but the take by Fishing Tour Operator (FTO) clients has grown in recent years with the introduction of larger charter vessels with a greater range.

Target species and Total Allowable Commercial Catch (TACC)

The majority of Saddletail and Crimson Snappers are harvested by trawl gear in the Demersal Fishery. The two species are managed together as “red snapper” with Saddletail Snapper comprising around 80% of the total red snapper catch.

Separate TACCs have been allocated to each of the offshore snapper fisheries. Red snappers have a combined TACC of 2500 t (~2000 t for Saddletail Snapper) in the Demersal Fishery and 1300 t (~1044 t Saddletail Snapper) in the TRF. In 2012, the total commercial catch of Saddletail Snapper was 1530 t (Demersal Fishery, 1338 t; TRF, 192 t).

Overview of species biology and stock structure

In common with other tropical snapper species, Saddletail Snapper is a slow growing, long-lived, widespread Indo-Pacific species found throughout tropical northern Australia. Males and females have different growth rates and maximum sizes, with males growing larger than females (Newman, 2002). The maximum observed length of 68 cm corresponds to a maximum age of 33 years (Fry and Milton, 2009). Natural mortality is low (0.115 - 0.16; Newman, 2002; O’Neill et al, 2012). Spawning occurs throughout the year, with a peak between September and March (Fry et al, 2009). The extended longevity and low natural mortality rates suggest this species is vulnerable to overfishing.

Genetic analyses indicate that there is little difference between populations of Saddletail Snapper across the Australian Arafura and Timor Seas, but that the Australian stocks are different to stocks of the species in several northern Arafura locations in Indonesia (Salini et al, 2006). These results suggest that the Australian populations of Saddletail Snapper may be vulnerable to impacts from Indonesian fishing close to the Australian border.

Previous assessments

The most recent assessment for “red snapper” (1996) estimated that the biomass of this group in 1990 was 24 000 t (Ramm, 1997). This estimate was based on trawl surveys conducted in 1990 and 1992 and took into account the earlier high fishing pressure from foreign fleets. In 1996 the estimate of annual sustainable yield for red snappers in the Arafura Sea was 2500 t and for the TRF the yield estimate ranged from 1300-2900 t (Ramm, D.C. 1994, 1997). The current TACCs for red snappers are based on those estimates.

METHODS

Stochastic Stock Reduction Analysis

The modelling approach used in these assessments is the same as that used in the stock assessment workshop conducted for selected NT fish species in 2011 (Grubert et al, 2013). Stock Reduction Analysis (SRA) is a population dynamics model consisting of life history parameters that describe the underlying production and carrying capacity of a population over time. Stochastic SRA uses MSY (maximum sustainable yield) and U_{msy} (annual harvest rate to achieve MSY) as leading parameters. Inputs include long term catch history, a time series index of abundance (Catch Per Unit Effort or other index of abundance) and age data.

The model simulates changes in biomass by subtracting estimates of mortality and adding new recruits, where the new recruits are a function of the current stock size and the leading parameters. Stochastic SRA provides probability distributions of leading parameters, and other population parameters, over time given alternative hypotheses about unfished recruitment rates and variability around the assumed stock-recruitment relationships. These distributions are generated by conducting a very large number of simulation trials and retaining those sample trials for which the stock would not have been driven to extinction by historical catches.

The SRA interface also generates a visual representation of the current state of the population based on the Pacific Fisheries Management Council (PFMC) 40/10 rule (Figure 2). The 40/10 rule states that when a stock is reduced to less than 40% of its unfished biomass (or in this case the egg production is less than 40% of the unfished egg production; vertical dotted line on Figure 2), it is considered overfished. At that point the target for the current harvest rate is gradually decreased from the harvest rate at maximum sustainable yield to zero at the point when the egg production is less than or equal to 10% of the unfished egg production. (Grubert et al. 2013; Lombardi and Walters, 2011).

The model also generates an output of the probability of overfishing in the year following the current year, based on the predicted catch for that year.

A detailed description of Stochastic SRA can be found in Walters et al (2006) and a summary in Grubert et al (2013).

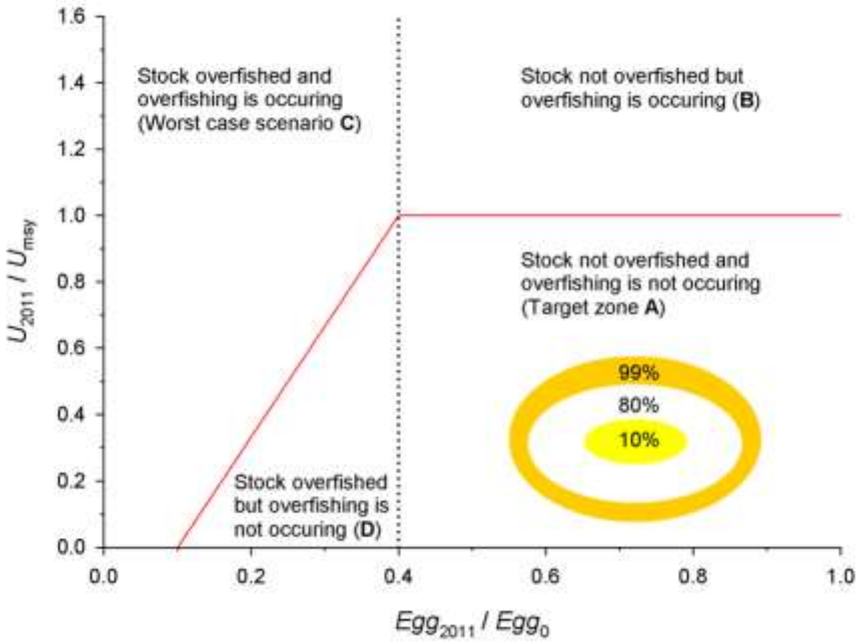

Figure 2. Representation of the PFMC 40/10 rule, showing four "status zones" and a probability plot of stock status located in the Target zone – not overfished and overfishing not occurring. The outer edge of each coloured region correspond to a 10%, 80% and 99% chance that the estimated status measures fall within that region. The horizontal red line represents the harvest rate at maximum sustainable yield and the diagonal red line represents the PFMC 40/10 rule. Source: Grubert et al. 2013.

Catch history

Foreign harvests

Data for historical foreign harvests across northern Australia were collated from databases held by various Commonwealth, State and Territory agencies as part of a recent Fisheries Research and Development Corporation (FRDC) project (O'Neill et al. 2011). Because there was little resolution to species level (e.g. "red snappers" consisted of six species) in the data, division into individual species was modelled using domestic logbook records. Data from the FRDC project have been used to reconstruct catch histories for the current assessments.

Domestic catch

Annual catch data for Saddletail Snapper were obtained from logbook records. Although this species and Crimson Snapper are combined for quota purposes, each species is logged separately in the daily catch and effort returns, therefore the catch and catch per unit effort (CPUE) data used here relate to Saddletail Snapper alone.

Given the low current catch of Saddletail Snapper in the recreational, Indigenous and FTO sectors, only data from the commercial fisheries have been used in these assessments.

Catch rates and spatial averaging

In the absence of fishery-independent estimates of relative abundance, commercial CPUE data were extracted from daily logbook records. However, CPUE data often do not provide a reliable source of information for quantitative stock assessment due to the non-random search behaviour of fishers. Averaging whole fishery CPUE data from fishers who move from one location to the next when catch rates begin to fall, can mask localised depletion thus providing a misleading representation of stock trends.

To overcome this problem, CPUE time series data were "spatially averaged" prior to the SRA (Walters, 2003). To prepare for spatial averaging, annual CPUE data for each (60 x 60 nm) fishing grid were entered into a spread sheet with a column for each year and a row for each grid cell that could have been fished. Empty grids (where no fishing had occurred) were filled as follows:

- grids for years prior to any fishing occurring were back-filled with the highest CPUE recorded during the years when fishing began in those grids;
- grids where fishing had occurred, but were no longer being fished were forward-filled with the last recorded CPUE; and
- empty grids in-between fished years were filled with the difference between the closest years CPUEs.

Catch rates for all grids within each year were then averaged to generate a spatially averaged CPUE time series. The rationale behind the filling of empty cells prior to fishing is that each grid would have supported enough of the target species for catch rates to have been at least as high as the highest CPUE after initial exploration.

Age and mortality data

Age information for Saddletail Snapper in NT waters is limited. Age data from 1990 (showing high numbers of young fish) and limited samples from 1991-1993 suggested that at that time the population may have been recovering from the high levels of foreign fishing. Total mortality rate (Z) was estimated to be 0.21. M (0.11-0.16) and F (0.06-0.1) were low. Saddletail Snapper were assumed to have the same vulnerability after full recruitment to the fishery (at age 5).

RESULTS

Catch history and spatial averaging

Saddletail Snapper was one of a number of "red snapper" species that were heavily exploited by foreign fishing operations from the early 1970s to 1990 (Figure 3). Domestic harvest was very low until 1995 when the trawl vessel began operating. Since then catches have increased steadily, plateauing around 1000 t in 2008. The increased catch in 2012 is a result of the entry of two new trawl vessels under the ITQ management arrangements.

The spatially averaged trawl catch rate has been reasonably stable around 1600 kg per boat day, apart from a peak of 1874 kg per boat day in 2006.

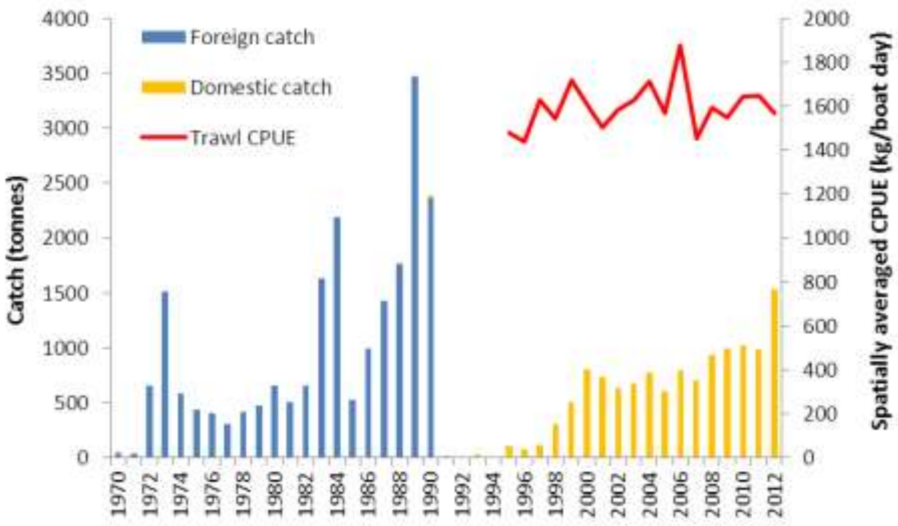

Figure 3. Catch and spatially averaged CPUE (kg per boat day) for the combined harvest of Saddletail Snapper by the Timor Reef and Demersal Fisheries.

Model outputs

The model was run using a range of values for the current harvest rate (0.06 to 0.10) to find a scenario that generated the best fit to the estimated stock size in 1990 (20,000 t - NT trawl survey; Ramm, 1997). For all tested scenarios, the stochastic SRA for Saddletail Snapper indicated that despite high exploitation levels prior to 1990 and the steadily increasing domestic catch, the population is not currently overfished (Figures 4 and 5). Using a current harvest rate of 0.08, there was no indication that overfishing is occurring. Current egg production was estimated to be around 80% of that prior to any fishing activity and the harvest rate is below that required to achieve maximum sustainable yield.

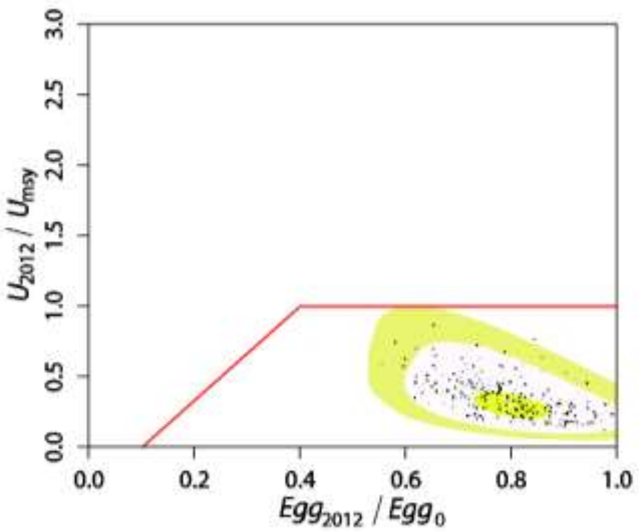

Figure 4. Stock status output from the stochastic SRA of the combined Saddletail Snapper harvest by the Timor Reef and Demersal Fisheries. The position of the probability distribution indicates that the Saddletail Snapper stock in the Arafura and Timor Seas is not overfished and overfishing is not occurring.

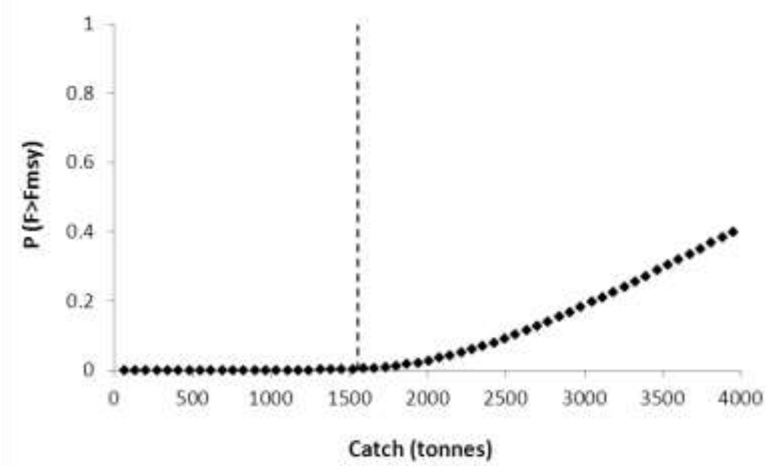

Figure 5. Predicted probability of overfishing (F>Fmsy) Saddletail Snapper at increasing harvest levels by Timor Reef and Demersal Fisheries. The vertical dotted line represents the 2012 combined catch (1530 t) indicating that overfishing is not currently occurring.

DISCUSSION

The results presented here indicate that Saddletail Snapper is currently being fished sustainably. Using the 1990 biomass estimate for red snappers in the Arafura Sea, the SRA indicated that harvest rate was low between the years of 1990 and 2011 when foreign fishing had ceased and only one domestic trawler was operating in the fishery. Annual sustainable yields for Saddletail Snapper were estimated to be in the region of 1500-2000 t. Extrapolating this estimate to include Crimson Snapper results in a sustainable yield of 1800-2400 t for combined red snappers.

Since the last analysis of red snappers in 1996, we have gained a greater understanding of many aspects of the fisheries targeting Saddletail Snapper including:

- the biology and stock structure of the target species;
- the geomorphology and habitat structure of the fishing grounds;
- fine scale catch and effort information; and
- fishery operations.

Detailed data are lacking on the Indonesian catch, but Indonesian fishery statistics suggest that red snappers are highly valued and still reasonably common in their demersal catches across the Arafura and Timor Seas (unpublished data). Illegal fishing in Australian waters has been greatly reduced through improved surveillance.

In the previous assessment, there was concern about the fishing technique in use at the time which involved precise targeting of snapper aggregations with short trawl durations. This technique meant that CPUE could not reliably be used to monitor stock status. Since then, the main fishing method has changed to targeting red snapper grounds with longer trawls. This method has provided more reliable catch rate data which indicate that in the most productive areas of the fishery current biomass may be higher than the estimate made in 1990. This information must be independently verified, as catch rate data – even using the current fishing methods – are inherently biased towards higher estimates as fishers will target the most productive grounds and avoid areas with lower densities of the target species.

With the introduction of ITQ in February 2012, and the subsequent entry of two more trawl vessels, catch increased immediately by around 50%. Further increases are likely as skippers become more familiar with the fishery (or more operators enter the fishery). This is expected to result in a rapid increase in harvest rate. With increasing catches, it is critically important that a fishery-independent method for gathering relative biomass and stock trend information be developed and implemented. Previous assessments of biomass are more than 20 years old and were perhaps affected by high levels of foreign fishing in the years leading up to the 1990 trawl survey. It could be assumed that stocks have recovered from those early years of high exploitation, however without independent stock trend information this assumption cannot be tested.

Of the methods available to estimate current harvest rate, the conventional tag-recapture approach is not possible owing to the susceptibility of deep water fish to barotrauma. Novel techniques using in situ tagging (either genetic tagging or other underwater tagging technology) are possibilities but are expensive and complex to develop. The most effective method for this species is to obtain a reliable time series index of biomass through regular fishery-independent surveys. Such surveys would also provide regular, large samples of fish for ageing.

CONCLUSION AND RECOMMENDATIONS

The current harvest rate of Saddletail Snapper is sustainable. Outputs of the SRA indicate that the probability of overfishing will increase gradually as catches approach the TACC. Given the expected increase in effort as a result of the introduction of ITQ, catches are expected to reach the TACC within the next year or two. Until a better estimate of the relative biomass and the current harvest rate for both species is available, it is recommended that there be no change to the TACC.

Recommendations

- No change to the current TACC;
- Obtain regular fishery-independent indices of biomass using “swept area” surveys;
- Determine spatial variation in growth parameters and stock structure;
- Continue to monitor spatial CPUE trends;
- Review the appropriateness of current management trigger points as improved knowledge of stock structure, growth and biomass responses to fishing become available;
- Include FTO catch statistics (and recreational catch statistics if possible); and
- Continue to work with Indonesian fisheries managers to obtain spatial catch and effort data from vessels targeting these species in Indonesian waters.

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APPENDIX A: Glossary of abbreviations and terms

CPUE	Catch per Unit Effort
Egg	Total egg production in a given year (as a subscript: Egg_{2012})
F	Fishing mortality rate
FRDC	Fisheries Research and Development Corporation
FTO	Fishing Tour Operator
ITQ	Individual Transferrable Quotas
M	Natural mortality rate
MSY	Maximum Sustainable Yield
NT	Northern Territory
PFMC	Pacific Fisheries Management Council
SRA	Stock Reduction Analysis
t	tonne
TACC	Total Allowable Commercial Catch
TRF	Timor Reef Fishery
U	Harvest rate
U_{msy}	Annual harvest rate to achieve MSY
Z	Total mortality rate

APPENDIX B: Screen capture of SRA interface