Appendix 4: Background materials provided to participants prior to the workshop.

Coral reef fin fish spawning closures

Risk assessment workshop

12 – 13 May 2009
9am – 5pm
Russell 1 & 2
Berkley's On Ann
Rendezvous Hotel Brisbane
255 Ann Street, Brisbane

THE UNIVERSITY OF MELBOURNE

Queensland Government

Background

This workshop will explore candidate alternatives for spawning closures to be applied 2009 – 2013.

The *Fisheries (Coral Reef Fin Fish) Management Plan 2003* introduced three nine-day spawning closures for coral reef fin fish on the Great Barrier Reef (GBR). The closures applied to the new moon periods in October, November and December for the years 2004-2008. On the basis of advice regarding the biological effectiveness of the December closure and the high costs to fishers the December closure was removed in 2008.

The 2004 – 2008 closures were designed to provide protection to the key commercial target species, coral trout. The peak spawning periods of coral trout are reasonably well known. While critical to the commercial sector, coral trout is of lesser importance to recreational and charter-based fishing. A relative lack of information on the spawning habits of other species has lead to a tendency to place lesser emphasis on their consideration. A more comprehensive assessment could consider:

a. Coral trout (*Plectropomus* spp. & *Variola* spp.)

b. Red throat emperor (*Lethrinus miniatus*)

c. Red emperor (*Lutjanus sebae*)

d. Large mouth nannygai (*Lutjanus malabaricus*)

e. Spangled emperor (*Lethrinus nebulosus*)

f. Camouflage grouper (*Epinephelus polyphekadion*)

g. Flowery cod (*Epinephelus fuscoguttatus*)

h. Greasy rockcod (*Epinephelus tauvina*)

i. Spanish flag (stripey; *Lutjanus carponotatus*)

j. Tuskfish (*Choerodon* spp.)

Closures targeting coral trout afford some protection to other coral reef fin fish species, although the magnitude of this effect is speculative. The imperative to explicitly consider other species rests on judgments concerning

- the importance of each species to each sector,
- the importance of each sector, and
- the capacity of existing controls other than spawning closures to provide adequate protection.

These judgments are a central theme of the workshop.

An initial task for the workshop is identification of candidate alternatives. Any closure regime implemented beyond 2008 needs to provide adequate protection for spawning coral reef fin fish species, within a constraint that the impost on commercial and recreational (including charter) fishing is no greater than for the period 2004 – 2008. ReefMAC has recommended a five year package comprising two years (2009-2010) of no spawning closures followed by three years (2011-2013) of two nine-day spawning closures (around the October and November new moons of each year; six days prior to the new moon and two days following the new moon).

Other alternatives may include elements that address

- Different timing of closures (moon phase, month and duration).
- Species-specific closures.
- Exemptions for specific sectors (e.g. the extended charter fleet).

The focus of the workshop is assessment of the merit of alternative *spawning closure regimes* in terms of their capacity to provide *adequate protection* to the *fishery*. It does *not* seek to directly address broader socio-economic issues, conservation-dependent species (or communities), or changes to other management controls (e.g. allowable catch, bag limits etc.).

2 Identified from the Ecological Risk Assessment of the Other Species component of the Coral Reef Fin Fish Fishery, 'species of special interest' from the Workshop Summary: Management and Science of Fish Spawning Aggregations in the GBRMP July 2007, or target coral reef fin fish species from conditions of filleting permits issued by the DPI&F.

Objectives

- Identify a shortlist of candidate alternatives for spawning closure regimes.
- Characterise uncertainty in the merit of alternatives.
- Provide advice on an appropriate closure regime for the period 2009 – 2013.

Preparatory readings

Extract from: Tobin, R.C., Simpfendorfer, C.A., Sutton, S.G., Goldman, B., Muldoon, G., Williams, A.J., Ledee, E. (unpubl.). *A review of the spawning closures in the Coral Reef Fin Fish Fishery Management plan 2003*. **Draft Report** to the Queensland Department of Primary Industries and Fisheries. February, 2009. Fishing and Fisheries Research Centre, School of Earth and Environmental Sciences, James Cook University.

Extract from Anon. (2009). *Annual status report 2008. Coral Reef Fin Fish Fishery*. The State of Queensland, Department of Employment, Economic Development and Innovation.

Agenda

Berkley's On Ann, Rendezvous Hotel Brisbane
255 Ann Street, Brisbane

Time	DAY 1 – Tuesday 12 May
9.00	Problem formulation 1: key species and candidate spawning closures
10.30	Morning tea
10.50	Problem formulation 2: an endpoint for 'adequate protection'
12.00	Assessment of alternatives for two species
12.30	Lunch
1.20	Assessment of alternatives for all species
3.00	Afternoon tea
3.20	Cross-examination of perspectives
4.15	Identifying key trade-offs and uncertainties
5.00	Close
6.30	Evening dinner (optional)

Time	DAY 2 – Wednesday 13 May
9.00	Confronting trade-offs: weighing the importance of fish species
10.30	Morning tea
10.50	Discussion of outcomes issues overlooked contrasts in perspectives insights for monitoring and research implications for decision-making
12.30	Lunch
1.20	Exploring localised effects
3.00	Afternoon tea
3.20	Risk ranking
4.00	Report and discussion of outcomes
5.00	Close

Extract from: Tobin, R.C. *et al.* **(unpubl.).** *A review of the spawning closures in the Coral Reef Fin Fish Fishery Management plan 2003.* **Draft Report to the Queensland Department of Primary Industries and Fisheries. February, 2009. Fishing and Fisheries Research Centre, School of Earth and Environmental Sciences, James Cook University.**

Summary

The review of biological information relevant to the consideration of the current spawning closure regime in place for the Queensland Coral Reef Fin Fish Fishery (CRFFF) utilised both published information and unpublished data from the Effects of Line Fishing Project. The analysis showed:

The previous three 9-day spawning closures over the new moon periods of October, November and December provide some protection for spawning individuals of a range of species in the fishery.

The main exception to this is the red throat emperor, which spawns during winter and spring.

An analysis combining information on the readiness to spawn and the importance in the commercial catch demonstrated that there are significant differences in the effectiveness of closures for the protection of spawning stocks, with October being the month that had the highest potential to protect spawning commercial stocks of coral reef fish. A similar analysis could not be completed for the recreational sector because of a lack of detailed catch data.

None of the currently fished CRFF species showed substantially higher levels of catch during spawning months than during non-spawning months.

Limited data was available on the timing of spawning relative to moon phase. The available published data demonstrates that there is considerable variation in the timing of spawning relative to moon phase. Some species spawn mostly around new moon periods (e.g. coral trout), while other species spawn on full moons and others show no lunar periodicity.

Seasonal (monthly) patterns in reproductive activity

Published studies provided information on the reproductive biology of 18 species of fish from the GBR. This included three species that are not recorded as having been taken in the CRFFF and two that are currently protected by legislation. There was considerable variation in both the length and timing of spawning season among species (Figure 1). Generally, the majority of species spawn in the spring and summer months. One species was reported to spawn all year (*Parapercis cylindrica*) while some, notably *Lethrinus miniatus* and *L. nebulosus* are winter-spring breeders. For all exploited species except *L. nebulosus*, at least one month of spawning occurs within the months of the previous spawning closures. The spring-summer spawning season for *P. leopardus* is further confirmed by work of Light and Jones (1997) who found larval recruits from October through February.

Lunar patterns

The few studies published on GBR fishes are summarised in Table 1. There are many species which spawn throughout the lunar month; some, particularly the serranids, spawn predominantly around new moon, and a minority follow semi-lunar activity. The data are too few, however, to enable the formulation of any generalisations at this stage.

Coral trout are well documented as spawning around the new moon period, but there is no published information on the lunar timing of the spawning of other key target species such as *Lutjanus miniatus, L. sebae, L. malabaricus* and *L. erythropterus*. Kritzer (2004) demonstrated *Lutjanus carponotatus* spawns around the new moon similar to coral trout. It is possible that some fishes in the GBR CRFFF do not spawn monthly, as *Lutjanus vittus* from the North West Shelf of Australia follows a semi-lunar pattern of spawning 3 days after new moon and 6 days after full moon (Davis and West 1993).

Proportion of catch taken during spawning months

The proportion of the commercial catch taken during spawning months was determined for 14 species, including 4 protected species (Figure 3). Only one species, Maori wrasse (*Cheilinus undulatas*), showed a proportion of catch much greater than 0.0833, suggesting that prior to their protection that they were mostly caught during spawning months. Three important commercial species - common coral trout (*Plectropomus leopardus*), red throat emperor (*Lethrinus miniatus*) and flowery cod (*Epinephelus fuscoguttatus*) - had values that suggested that slightly greater proportions of catch were taken during spawning periods. All other species had catch proportions below 0.0833, indicating that proportionally more catch was taken during non-spawning months.

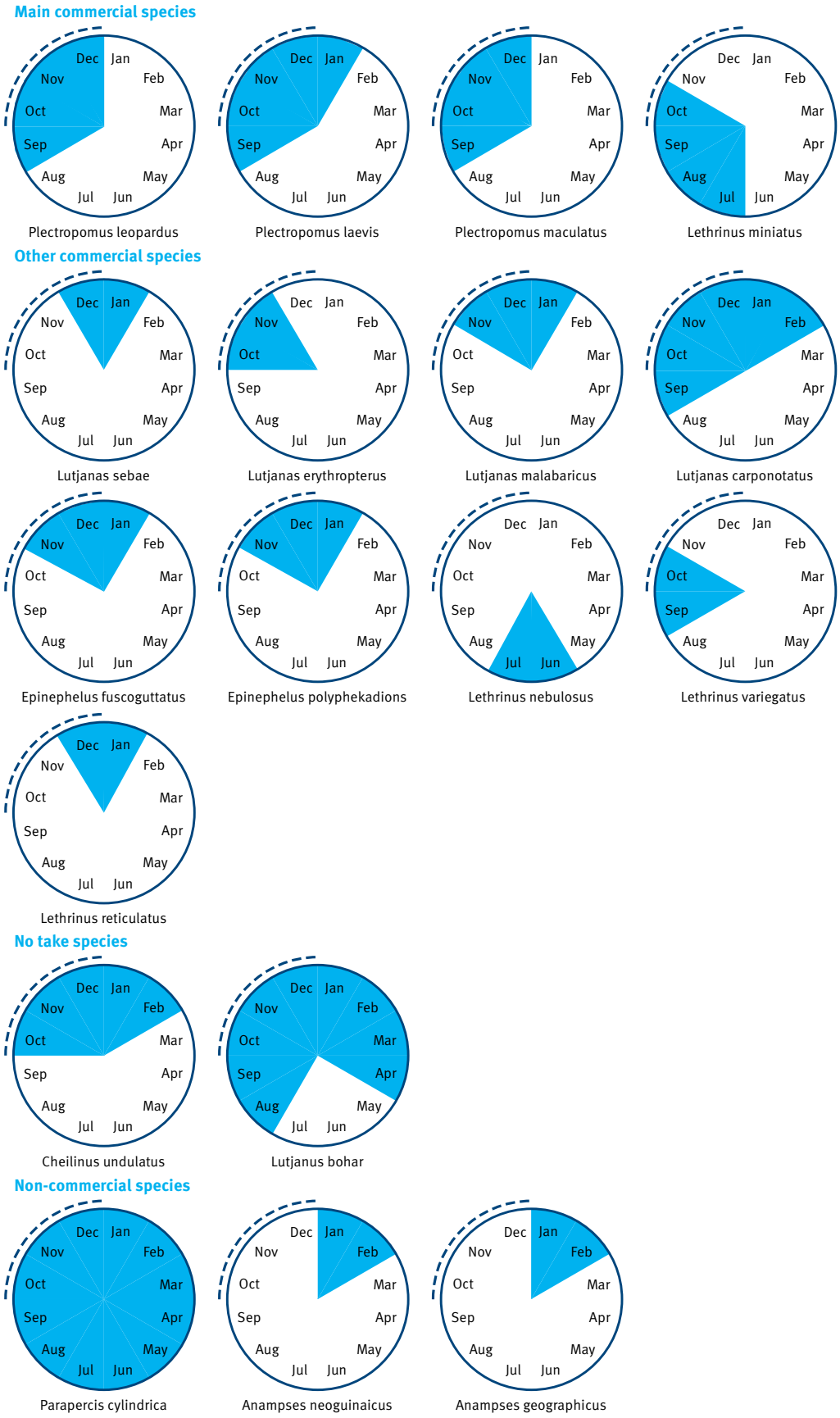

Figure 1. Reproductive seasons of commercial reef fish spawning on the GBR derived from literature. Grey regions indicate months in which significant reproductive activity has been recorded. The dotted line indicates the months in which there are currently 9-day closures to fishing.

Discussion

Monthly patterns of spawning activity

The information reported in this review provides a broad view of the reproductive biology and spawning activity of economically important coral reef fish species that occur within the waters of the Great Barrier Reef. The results of the analysis of the timing of spawning activities demonstrated that the majority of species taken by commercial and recreational fishers do so during at least one of the months of the current three 9-day closures during the new moon periods of October, November and December. There were few reports of spawning in these species between February and August (inclusive). The one exception to this was the red throat emperor which spawned during winter months. These data suggest that the timing of the current closures protect at least some spawning activity of the majority of coral reef fish species on the GBR.

The timing of the spawning in the key coral reef fish species on the GBR is also likely to be a function of latitude due to water temperature effects (Claydon 2004). Evidence for possible regional differences in the timing of spawning comes from several species of emperor that follow different patterns in Noumea than they do on the GBR and may respond to water temperature rather than time of year (Church 1995; Loubens 1980; Sheaves 2006; Williams et al. 2006). It should also be noted that changes in water temperatures associated with climate change could effect the timing of spawning activities, however, insufficient data are currently available to predict what these changes may be, or if they will occur.

It is known that the species composition of the recreational sector is substantially different from that of the commercial sector. Common coral trout is much less important in the recreational sector, while emperors and "reds" (*Lutjanus sebae, L. malabaricus* and *L. erythropterus*) are much more commonly taken (Simpfendorfer et al 2007). This difference in the species composition means that the effectiveness of the timing of closures for the recreational sector may be different than for the commercial sector.

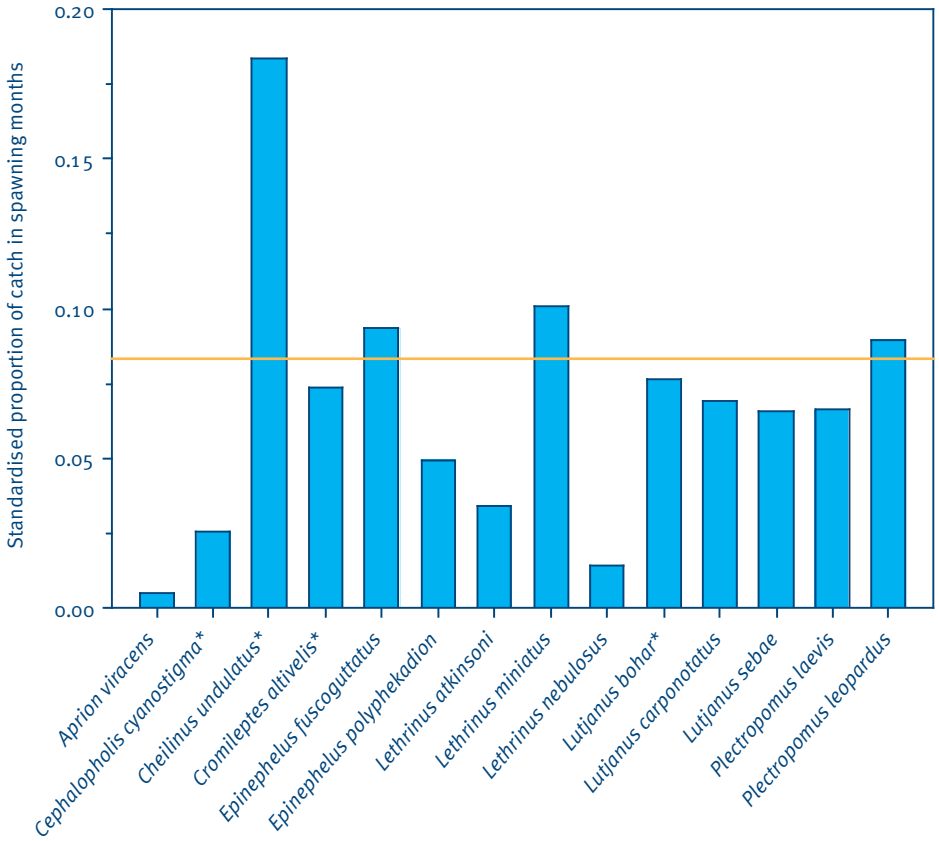

Figure 3. Proportion of the commercial catch taken in spawning months for major species in the CRFFF. Current no-take species are indicated by astrices. Reference line indicates the point at which equal proportions of catch would be taken in all months. Species above the line indicate those in which more catch was taken in spawning months than in non-spawning months. Based on QDPI&F CFISH data from 1998 to 2004. No-take species included those protected by legislation and those that do not reach the 38 cm minimum size length for serranids.

Table 1. Published records of reef fish spawning relative to lunar phase in Great Barrier Reef waters.

Family and species	Lunar stage	Lunar days	Location	Reference	Data
Lutjanidae					
Lutjanus carponotatus	New Moon	1	GBR	Kritzer J P, 2004	Field and laboratory studies
Lutjanus erythropterus	Distributed throughout full lunar cycle		Innisfail to Cooktown	McPherson G R et al., 1992	Fishery data
Lutjanus malabaricus	Distributed throughout full lunar cycle		Innisfail to Cooktown	McPherson G R et al., 1992	Fishery data
Lutjanus sebae	Distributed throughout full lunar cycle		Innisfail to Cooktown	McPherson G R et al., 1992	Fishery data
Pinguipedidae					
Parapercis cylindrica	bi-monthly at new and full moon		from Lizard Is to One Tree Island	Walker , 2007	Field and laboratory work
Pomacentridae					
Pomacentrus wardi	1st and 3rd quarter		One Tree Island	Doherty P, 1983	Field work
	1st and 3rd quarter		One Tree Island	Doherty P, 1983	Field work
Serranidae					
Epinephelus fuscoguttatus	may spawn throughout much of the lunar cycle	16 27	GBR	Pears R J et al., 2007	Field and lab (histological) work
Epinephelus	may occur throughout much of the lunar cycle		GBR	Pears R J et al., 2007	Field and lab (histological) work
Plectropomus leopardus	New Moon		off Townsville	Frisch A I et.al. , 2007	Field and laboratory work
	New Moon	1	Scott Reef	Samoilys M A and L C Squire, 1994	Field and laboratory work
	New Moon	1	Lizard Island	Zeller DC, 1998	Field observations
	New Moon	1	Lizard Is to Townville	Brown I W et al., 1994	Field and laboratory work
	New Moon	27 2	Orpheus Island, Hayman, Keppel etc.	Frisch A I and L van Herwerden, 2006	Field and laboratory work
	New Moon, flooding tide	29 5	Scott & Elford Reefs	Samoilys M A, 1997	Field and laboratory studies
Plectropomus maculatus	New Moon	27 2	Orpheus Island, Hayman, Keppel etc.	Frisch A I and L van Herwerden, 2006	Field and laboratory work
Tetraodontidae					
Canthigaster valentini	all phases		Lizard Island	Gladstone W, 1987	Field work
	no lunar cycle		Lizard Island	Gladstone W and M Westoby, 1988	Field work

For example, "reds" are reported to more commonly spawn during the summer, and so greater protection of the spawning of species important to the recreational sector may be achieved during this period. However, until detailed catch data are available for the recreational sector it will be difficult to determine the most appropriate timing for closures to protect recreationally important coral reef fish species on the GBR.

One of the assumptions required for the use of spawning closures is that spawning fish are more vulnerable during these periods. Previous studies on the GBR have not been able to demonstrate that the main commercial species have a significantly higher catchability during spawning periods. Mapstone et al (2001) could not find evidence for increased catch rates during spawning periods of common coral trout, but did find some evidence that red throat emperor catch rates were elevated during spawning months. The analysis of the proportion of catch taken during spawning months in this review only identified the Maori wrasse as having a substantially larger proportion of the catch taken during spawning periods. Since this species is currently protected by legislation, spawning closures will not provide any further protection. The analysis also identified slightly greater proportions of catch taken during spawning months in three other species. Since these data do not take account of differences in fishing effort between months these results should be interpreted with caution.

Lunar timing of spawning

Lunar synchronisation in reef fish spawning behaviour is well know and documented for many species throughout the Indo-Pacific and Caribbean regions (Hamilton et al. 2004; Johannes 1981; Colin et al. 2003). From the reviews of Russell (2001) and Claydon (2004) we know that spawning in many GBR fish species is also related to lunar phase.

However, while coral trout spawn primarily around the new moon, this timing is not universal amongst other CRFF species and is likely to vary among species. For most CRFF species, lunar patterns are not well defined and there are too few data to generalise or make predictions as to the lunar timing of their peak in reproductive activity. Some very preliminary generalisations can be made – coral trout and many other species indicate a preference to spawn on new moons, although spawning behaviour has been documented during the full moon phase for common coral trout (Samoilys 1997). We also know that the time of spawning does not follow predictable patterns within taxonomic groupings – some members of a family may spawn on new moon, others on full moon, while others may spawn throughout the month. Within the lutjanids for example, *Lutjanus carponotatus* spawns over new moon, *L. cyanopterus* and *L. jocu* spawn over full moon, and *L. erythropterus*, *L. malabaricus* and *L. sebae* spawn throughout the lunar cycle (Heyman et al. 2005; Krajewski and Bonaldo 2005; McPherson et.al. 1992).

The timing of the current spawning closures over new moon periods therefore provides variable protection to spawning activities within the months that they occur. Species that spawn mostly on new moons (e.g. common coral trout) will receive better protection than those that do not. However, further research will be required to fully understand the timing of spawning relative to moon phase for coral reef fish species on the GBR and hence evaluate the timing of the current closure regime.

Conclusions

The current review of biological information suggests that the previous three 9-day closures protect at least some spawning of the majority of important coral reef fish on the GBR. Detailed analysis suggests, at least for the commercial sector, that there is variability in the effectiveness of these closures because of differences in spawning intensity between months. However, without more specific and detailed biological knowledge, it is currently difficult to assess exactly how effective the current spawning closures are in providing protection to reef fishes from over-exploitation throughout the entire GBR or for all sectors of the fishery. Significant information gaps exist, and should be addressed via targeting sampling of CRFF species within and outside of the assumed current spawning times along the length of the GBR to enable a more detailed understanding of timing of spawning. Further investigation is also needed into the occurrence of spawning aggregations, their size and distribution, as well as the response of spawning fish to fishing at the time of spawning. Further, research into movement of CRFF species into and out of green zones during spawning times would help determine the level of protection afforded these species by the GBR Zoning Plan. Regardless of these information gaps, the effectiveness assessment presented here provides a mechanism for managers to assess the relative impact that alternative spawning closures are likely to have in different months of the year. This will be particularly useful in a revision of the current closures. Any changes in spawning closures will need to consider the socio-economic impacts of such management changes.

Extracts from: Anon. (2009). *Annual status report 2008. Coral Reef Fin Fish Fishery.* The State of Queensland, Department of Employment, Economic Development and Innovation.

The following information has been updated following the workshop. The updated annual status report can be found at http://www.dpi.qld.gov.au/cps/rde/dpi/hs.xsl/28_14043_ENA_HTML.htm

Fishery profile 2007–08

Total harvest from all sectors: Approximately 4862 t[1]

Commercial harvest: Approximately 1807 t

Recreational harvest (2005): Approximately 2601 t

Indigenous harvest (2000–01): Approximately 108 t

Charter harvest: 346 t

Commercial Gross Value of Production (GVP): Approximately $40 million

Number of licences: 368 RQ fishing endorsements across the L1, L2, L3 & L8 fisheries[2]. 395 charter licences.

Commercial boats accessing the fishery: 237 primary vessels. Approximately 218 charter boats.

Fishery season: Coral reef fin fish are caught all year round. There are three 9-day closures that occur between October and December each year[3].

Source: Commercial Fisheries Information System (CFISH) database, 10 November 2008.

Table 2: Percentage of quota used for CT, RTE and OS in the 2007–08 financial year.

	Allocated quota	Quota minus DEWHA holdings	Total catch	% of available quota used
CT	1 423 982	1 288 158	1 158 107	90
RTE	693 630	618 986	233 227	38
OS	1 065 339	956 538	419 086	44

Source: Quota monitoring unit, 19 Dec 2008

1 For the purpose of this report, the total harvest estimate for 2007–08 includes the recreational harvest estimate from 2005, based on the assumption that the subsequent years of catch would be similar.

2 During the period Feb 06 – Dec 07 all L6 and L7 endorsements were replaced with L1 fishery symbols.

3 The spawning closure for December 2008 was removed

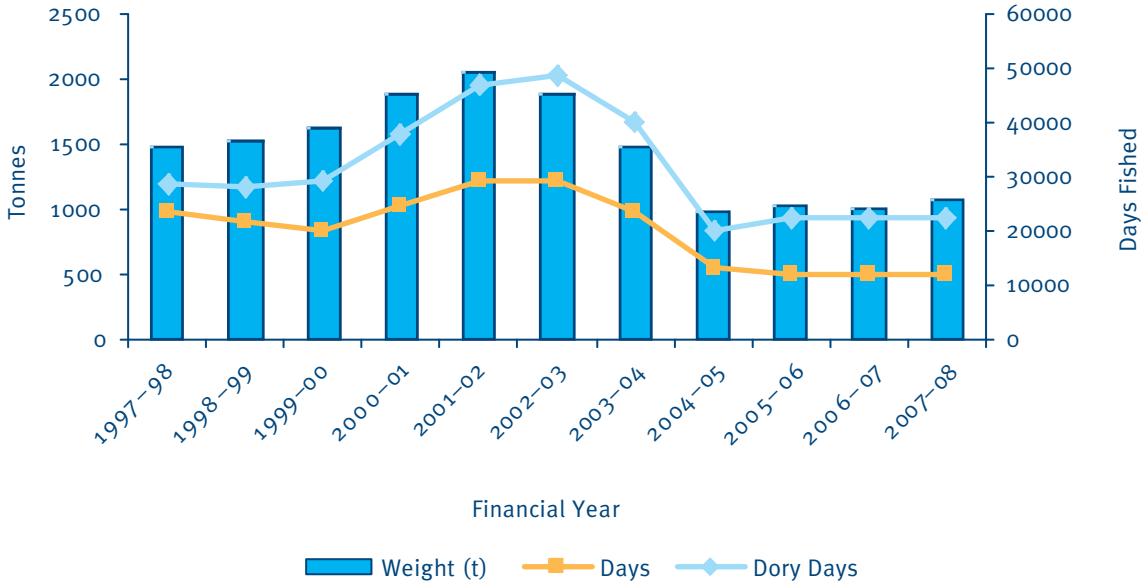

Figure 2: Total commercial catch and effort (days and dory days) of coral trout by quota year 1997-2008.

Source: CFISH database, 12 December 2008

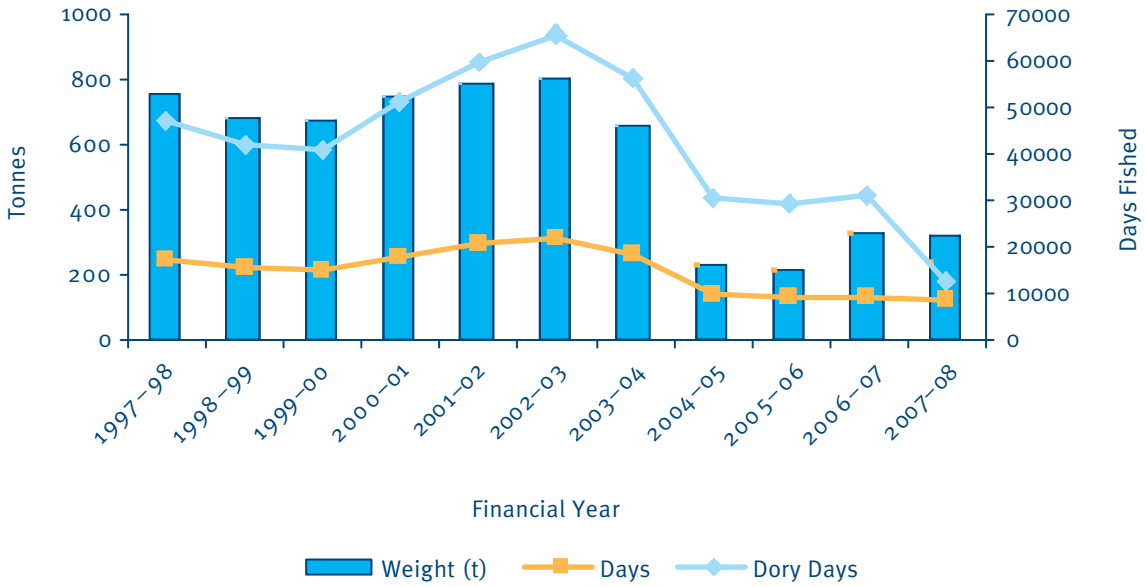

Figure 3: Total commercial catch and effort (days and dory days) of red throat emperor by quota year 1997–08.

Source: CFISH database, 12 December 2008.

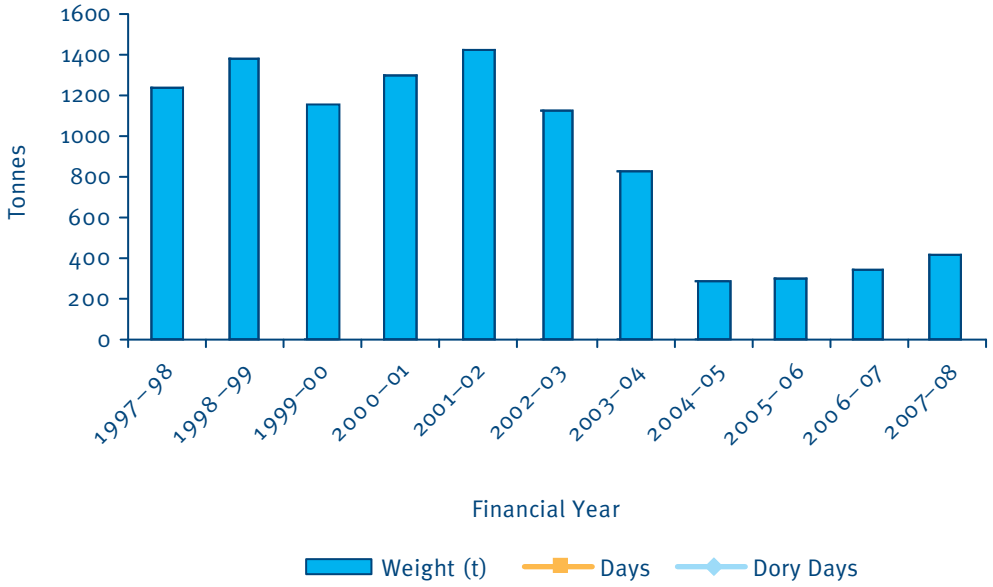

Figure 4: Total commercial catch of other species by quota year 1997-2008.

Source: CFISH database, 12 December 2008

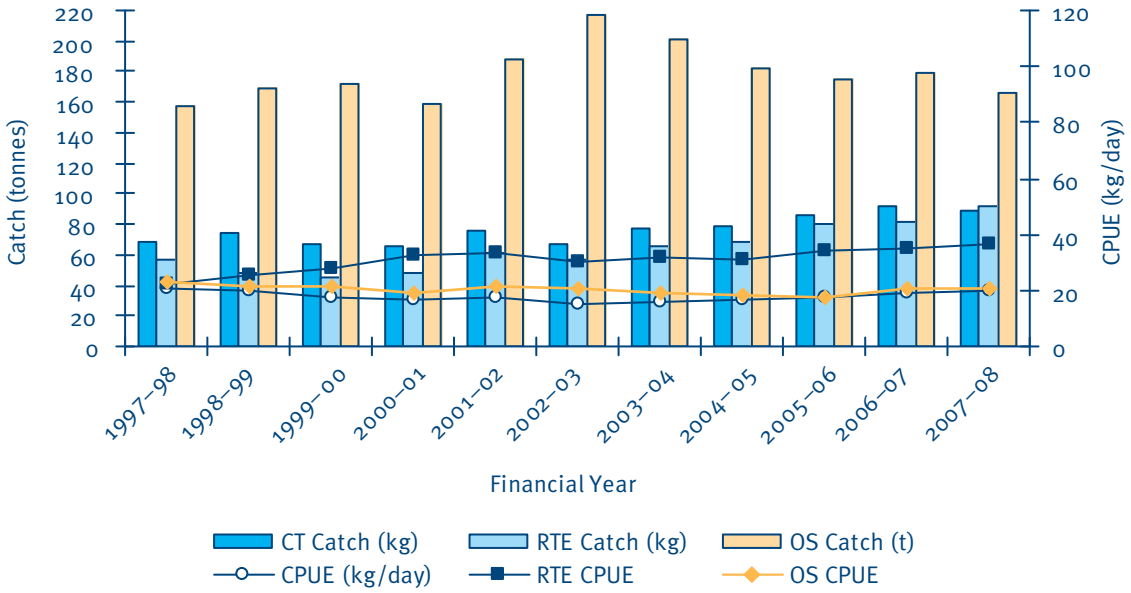

Figure 5: Charter catch of CT, RTE and OS species as reported in logbooks by financial year, 1997–98 to 2007–08.

Source: CFISH database, 12 December 2008.