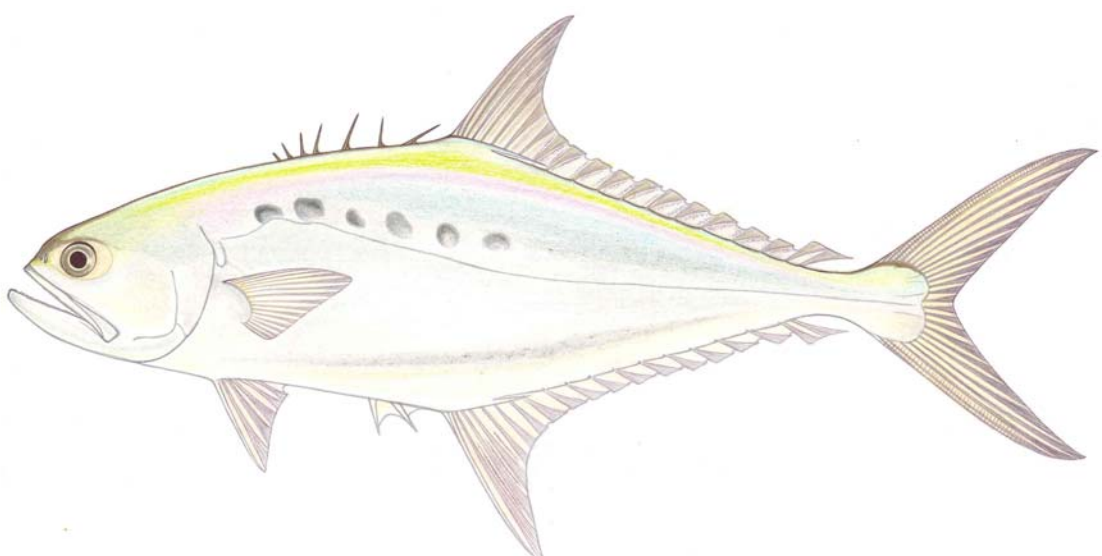
Age, Growth and Reproductive Dynamics of the Talang Queenfish (*Scomberoides commersonnianus*) in Northern Australia

Shane Griffiths, Gary Fry & Tonya van der Velde

Final Report



Talang queenfish (*Scomberoides commersonnianus* Lacepède, 1801)

Illustration courtesy of Bernard Yau (www.efishalbum.com)

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1. SUMMARY

The Talang queenfish, *Scomberoides commersonnianus* Lacepède, 1801, (family Carangidae) is the largest of four species of "queenfish" found throughout the Indo-West Pacific. They are an ecologically important component of coastal tropical ecosystems and are of increasing importance to commercial and recreational fisheries in Australia. The combined commercial and fishing tour operator (FTO) captures of queenfish in northern Australia have increased from 53 t in 1994 to 245 t in 2003, while the recreational catch was 177-387 t between 1999 and 2002. Despite the cosmopolitan distribution of queenfish and their growing importance to Australian fisheries, there is little understanding of their biology which is required to properly manage the species in the Northern Planning Area (NPA) in northern Australia. As a result, a research project was initiated in the Weipa region in northwestern Queensland to investigate their age, growth and reproductive dynamics.

A total of 327 queenfish (165 males and 162 females) were examined; ranging from 233 to 921 mm fork length (FL) and 0.157 to 8.210 kg. There was no statistical difference in the size distribution between sexes and the sex ratio was not significantly different from 1:1. Age and growth was estimated by counting growth bands in sagittal otoliths. Marginal increment analysis suggested that growth bands were formed annually between July and August. Estimated ages for fish collected in this study ranged from 0+ (no visible first band) to 11 years with the majority of fish between age 2-4 years old. There was no difference in growth between sexes. Queenfish grow rapidly early in life reaching lengths of 245, 379, and 493 mm FL at ages 1, 2 and 3 years, respectively. The von Bertalanffy growth parameters were estimated at L_∞ = 1196.9 mm FL, K=0.151 yr^{-1} and t_0=-0.518. Otolith weight was found to be a strong predictor of age. Estimates of natural mortality from growth parameters (M=0.341 yr^{-1}) was substantially lower than compared to similar sized tropical carangids; *Gnathanodon speciosus* (M=0.822 yr^{-1}) and *Carangoides bajad* (M=0.957 yr^{-1}). Fishing mortality (F) from recreational and commercial fisheries was estimated from age-based catch curves as 0.213 yr^{-1} and 0.484 yr^{-1}.

Reproductive dynamics was examined by histology which showed the length and age at which 50% of females mature (L_{50}) was 635 mm FL and 4-5 years. Histological data was not collected for males, but gonadosomatic index (GSI) data indicated that males probably mature earlier than females. Queenfish have a protracted spawning season extending from September to March with a peak in February, which largely coincides with the “wet” season in northern Australia. Although the actual spawning location of queenfish is unknown, spawning may occur offshore as fish captured offshore (7-10 nm) had ripe running eggs (late stage V). It was estimated that mature females produce an average of 1,327,827 ± 237,866 eggs per spawning.

The life history characteristics of *S. commersonnianus* are very different to other similar sized tropical carangids in that the species grows slower and reaches maturity later in life. Its life history characteristics are similar to a temperate carangid species, the silver trevally (*Pseudocaranx dentex*), which is believed to be overexploited as a result of their increasing fishing effort coupled the relatively slow growth and late maturity of the species. The neritic distribution of queenfish and their use of estuaries as nursery habitats may contribute to their populations also being vulnerable of becoming unsustainable if recreational and commercial catches continue to increase and appropriate management measures are not taken.

This research has filled some of the key knowledge gaps in the biology of Talang queenfish, which can provide a basis for stock assessment to guide management. However, implementation of a minimum legal length within the NPA may be a simple intermediate management measure that may ensure the sustainability of queenfish. Based on our estimates of length at sexual maturity (L_{50}) of females, we recommend an increase in the minimum legal length to 64 cm FL (72 cm total length) to ensure immature fish are not taken. We provide suggestions for further work on *S. commersonnianus* including: i) a genetic study to identify possible separate stocks, ii) life history studies in different regions across northern Australia, iii) further investigation of possible offshore spawning regions, iv) a preliminary stock assessment to assess their current exploitation level in northern Australia, and v) research on the post-capture survival of queenfish by recreational fishers in order to better estimate fishing mortality of released fish.

2. INTRODUCTION

Queenfish are a group of tropical pelagic fish species that are widely distributed throughout the Indo-West Pacific, inhabiting inshore and offshore reefs and estuaries. In Australia, the common name of "queenfish" actually comprises four species belonging to the family Carangidae; Talang or giant queenfish (*Scomberoides commersonnianus*), lesser queenfish (*Scomberoides lysan*), barred queenfish (*Scomberoides tala*) and needleskin queenfish (*Scomberoides tol*). The largest and most common species, *S. commersonnianus*, grows to a maximum size of 120 cm TL and 16 kg (Froese & Pauly, 2005), although individuals of half this size are more common.

In Australia, *S. commersonnianus* has a neritic distribution across the northern half of Australia extending from Shark Bay in Western Australia to at least Tweed Heads in northern New South Wales. Anecdotal accounts suggest their distribution is extended southward during summer and autumn (December to April) on the east Australian coast to at least Coffs Harbour in New South Wales (G Beers pers. comm. 2005). This is probably a result of the protrusion of warm water from the East Australian Current into southern waters during the summer and autumn months.

Talang queenfish are one of the most ecologically important components structuring tropical inshore ecosystems, particularly the estuaries throughout the Northern Planning Area (NPA), mainly owing to their relatively large size, high biomass and predatory nature. Blaber et al. (1989) estimated that *S. commersonnianus* represents between 25-32% of the total fish biomass in the Embley estuary. Their feeding ecology has been well studied in northern Australia including Weipa (Salini et al. 1990, Haywood et al. 1998), Groote Eylandt (Brewer et al. 1995) and the Norman River (Salini et al. 1998), while some limited dietary information exists for Dampier (Blaber 1986) and Exmouth Gulf in Western Australia (Loneragan et al. 2003). These studies show they are voracious predators consuming a range of prey items, but mainly dominated (in terms of biomass) by teleosts (90%), crustaceans (5%) and cephalopods (3%). Notably, Brewer et al. (1995) and Haywood et al. (1998) found that over 38% of queenfish sampled in the Weipa region consumed commercially important penaeid prawns. Considering the high densities of queenfish in Weipa estuaries (2.3-4.1 g m^{-2}) (Blaber et al. 1989), this species exerts considerable predation pressure on populations of commercially important prawns before they move from the estuaries and recruit to the Northern Prawn Fishery in the Gulf of Carpentaria.

2.1 Fisheries

Not only are queenfish an ecologically important component of tropical ecosystems, they are also a common and important component of inshore commercial and recreational fisheries in northern Australia, mainly the estuarine and inshore gillnet fisheries of Queensland (Qld) and the Northern Territory (NT). There are currently no specific management strategies in place in any Australian state commercial fishery to limit the take of queenfish as a target, byproduct or bycatch species. The take of queenfish by recreational fishers is managed in Qld and NT by bag limits and minimum legal lengths (MLL), but regulations differ by region. While there is not any take or possession limits for queenfish along the eastern Qld coast, in the Gulf of Carpentaria there is a MLL of 45 cm (QDPI&F 2005). In the Northern Territory there is a take and possession limit of 30 fish, but there is no minimum legal length (NTDBIRD 2005).

In Qld, reported commercial landings of queenfish (CHRIS 2005) have steadily increased in recent years from 59 t in 2000 to 168 t in 2003 (Fig. 1). There is some spatial variation in Qld queenfish catches with 85% of landings in 2003 being derived from the east coast of Qld. CPUE trends have also mirrored the total landings in Qld fisheries, increasing from 34 kg per day fished in 2000 to 59 kg per day fished in 2003 (Fig. 1). Net fisheries in 2003 contributed most to queenfish catches in Qld waters, comprising 96% (162 t), while line fisheries contribute only 4% (6 t). It is important to note that reported landings of queenfish by commercial and recreational sectors probably comprise more than one species, although the majority of this catch is thought to be *S. commersonnianus*.

In NT, annual commercial landings of queenfish are lower than in Qld and have fluctuated between 2.7 and 11.4 t between 1994-2004 (NTDBIRD Unpublished data; Fig. 2). No effort data was available to investigate trends in CPUE.

Queenfish are an important species for Fishing Tour Operators (FTO) and recreational fishers, owing to their fighting ability and reasonable eating quality. Queenfish are generally taken as a bycatch whilst targeting estuarine species, such as barramundi, and offshore species such as Spanish mackerel. The annual catch of queenfish caught by FTOs in Qld and the NT has rapidly increased in the past decade. In Qld the recorded number of fish caught per year increased from 83 fish in 1995 to 11074 fish in 2004 (CHRIS 2005), while in the NT annual queenfish catches increased from 856 fish in 1994 to 7987 fish in 2003 (NTDBIRD Unpublished data) (Fig. 3). It is important to note that the earliest catches may be lower due to a lower recording rate in logbooks. However, greater than 82% of queenfish are released post-capture by FTOs in Qld and NT (Fig. 3). Although accurate weights for fish landed are not available, QDPI&F estimated the average weight of queenfish caught by FTOs is 3.27 kg. Therefore, we estimate that the combined weight of queenfish landings by FTOs in Qld and NT is less than 65 t per year, and the total weight of fish released is less than 60 t per year.

There is only limited information available for recreational catches of queenfish, which is from recreational fishing diary programs in Qld (CHRIS, 2005). By assuming the average weight of queenfish taken by recreational fishers is the same as for FTOs (3.27 kg), it is estimated that the total catch for 1997, 1999 and 2002 was 177 t, 387 t, and 211 t, respectively. The percentage of the catch which was released ranged between 58-70% between 1997 and 2002. Overall, the total landings of queenfish by commercial fishers, FTOs and recreational fishers in Qld and NT may be in the vicinity of 455 t per year.

Despite the cosmopolitan distribution of queenfish and their growing importance to commercial and recreational fisheries in Australia, there has been no study undertaken on their biology including age, growth and reproductive dynamics. The paucity of biological information on queenfish species and the need for this data for future stock assessments in the Northern Planning Area was highlighted as a high priority by Williams et al. (2004). Following the release of this and other reports on key species groups in the NPA, the National Oceans Office provided a small amount of funding for projects which addressed one or more key information gaps by adding value to planned research in the NPA. The value adding could have been through joint research on the same species across the region or through expanding outcomes from research in a particular locality (eg estuaries, offshore). This study (one of two) was funded by the NOO as it supported cooperation between recreational and commercial fishers in the Weipa area, scientists and management agencies to address key information needs for the Talang queenfish.

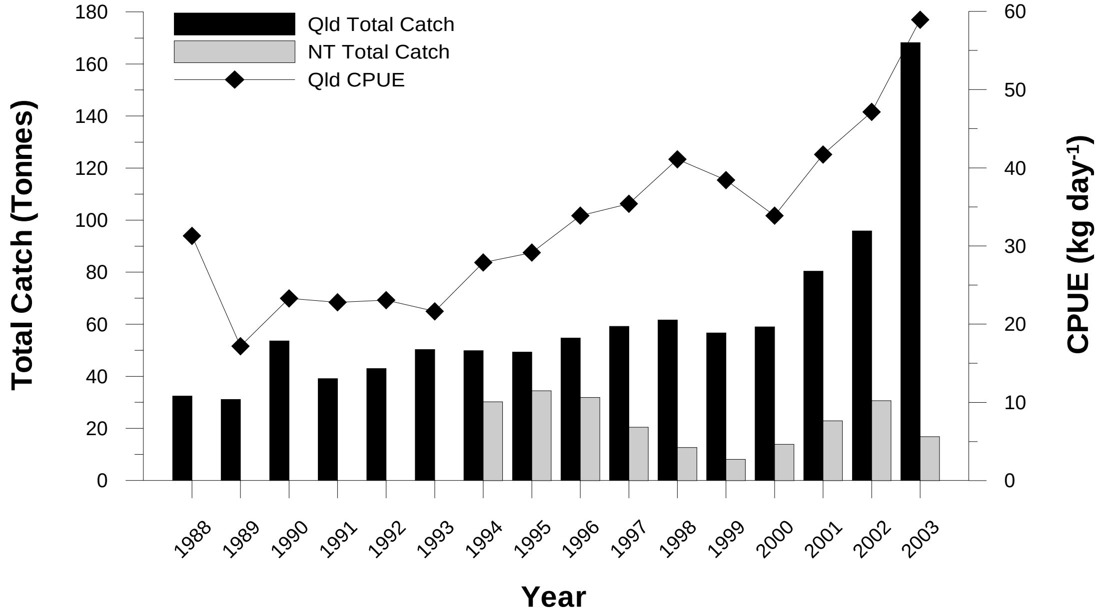

Figure 1. Total catches by year of queenfish taken in Queensland and Northern Territory commercial fisheries and CPUE (kg day^{-1}) in Queensland commercial fisheries only. Data sources are CHRIS 2005 and NTDBIRD unpublished data.

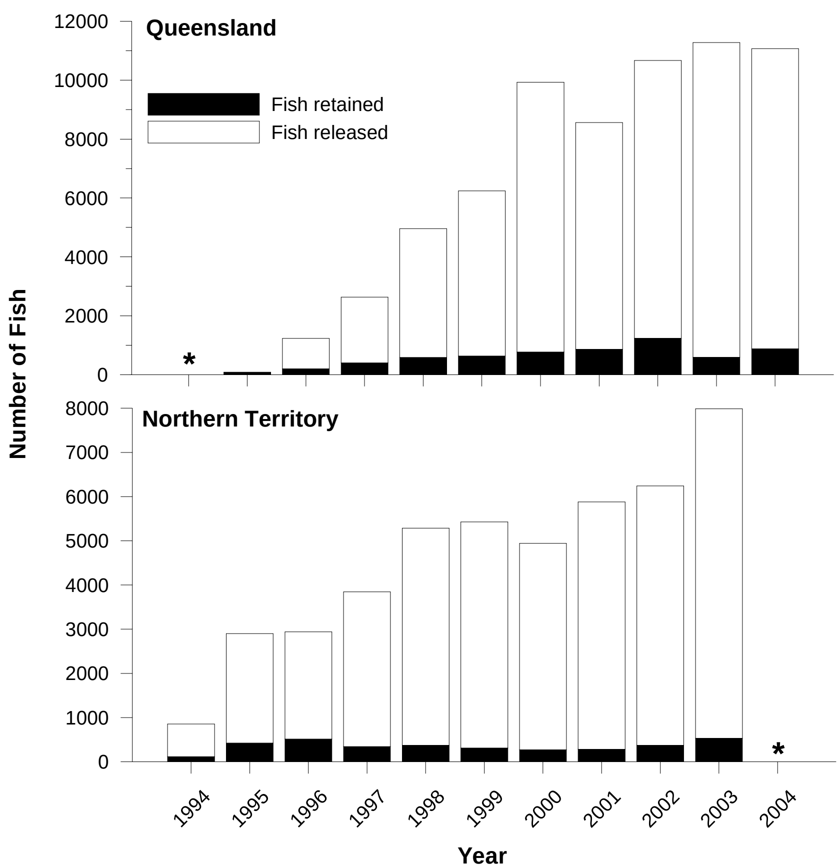

Figure 2. Number of fish retained and released by fishing tour operators in Queensland and Northern Territory between 1994 and 2004. Asterisks denote years where no data is available. Data sources are CHRIS 2005 and NTDBIRD unpublished data.

3. OBJECTIVES

The objectives of this study were to:

1. Estimate length-at-age and growth rates of the Talang queenfish using sagittal otoliths, with age validation using marginal increment analysis

2. Investigate the reproductive dynamics of queenfish, including:
    a. Timing of spawning, determined by a gonadosomatic index and histology
    b. Age and length at maturity
    c. Reproductive potential by quantifying batch fecundity of mature females

3. Provide a length-weight relationship

4. Collect tissue samples for inclusion in a genetic tissue bank, which will be available for use in future studies aiming to determine the genetic stock structure of queenfish.

4. METHODOLOGY

4.1 Description of the study region

This study was undertaken in a region defined by the National Oceans Office as the Northern Planning Area (NPA) (Fig. 3). This region covers over 700,000 square kilometres and incorporates the Torres Strait, Gulf of Carpentaria and eastern Arafura Sea to a line coinciding with the Goulburn Islands (133°23’ E) and is bounded latitudinally within 10° S and 18° S. The region encompasses both state and Commonwealth waters from the high tide mark out to the boundary of Australia’s Economic Exclusion Zone (EEZ). Owing to the large size of the NPA and the available resources, the study area was restricted to the Weipa region, which was thought to provide a representative region for the NPA (Fig. 3).

The Weipa region is characterised by a monsoonal climate with a pronounced “wet” season between December and March where moist westerly and north-westerly winds predominate and air temperatures average 35° C. During the wet season the region often experiences the effects of tropical cyclones, which are often concentrated in the Gulf of Carpentaria, which bring heavy rain, strong winds and storms surges. The remainder of the year is generally dry and warm with trade winds that persist from the southeast and east and air temperatures average 31° C. Average annual rainfall at Weipa is 1700-2000 mm with most occurring during the wet season (Bureau of Meteorology unpublished data).

The tidal range affecting the Gulf of Carpentaria is generally less than two metres, although the range and periodicity of tides around Weipa is complex. Normally there are two tidal cycles per day, but there are sometimes days where there is only one high and one tidal cycle each day. Also, there are days where the high and low tides only vary by a few centimetres (Blaber et al. 1994). This unusual tidal regime is mainly caused by a buffering effect of tidal energy by the islands and shallow reefs of the Torres Strait as water moves from the Coral Sea into the Gulf of Carpentaria. Water surface temperatures around Weipa can be considered high; ranging between 25-32° C but generally averaging around 28° C for most of the year (CSIRO unpublished sea surface temperate data). Further detailed descriptions of the physical environment of the NPA can be found in NOO (2003).

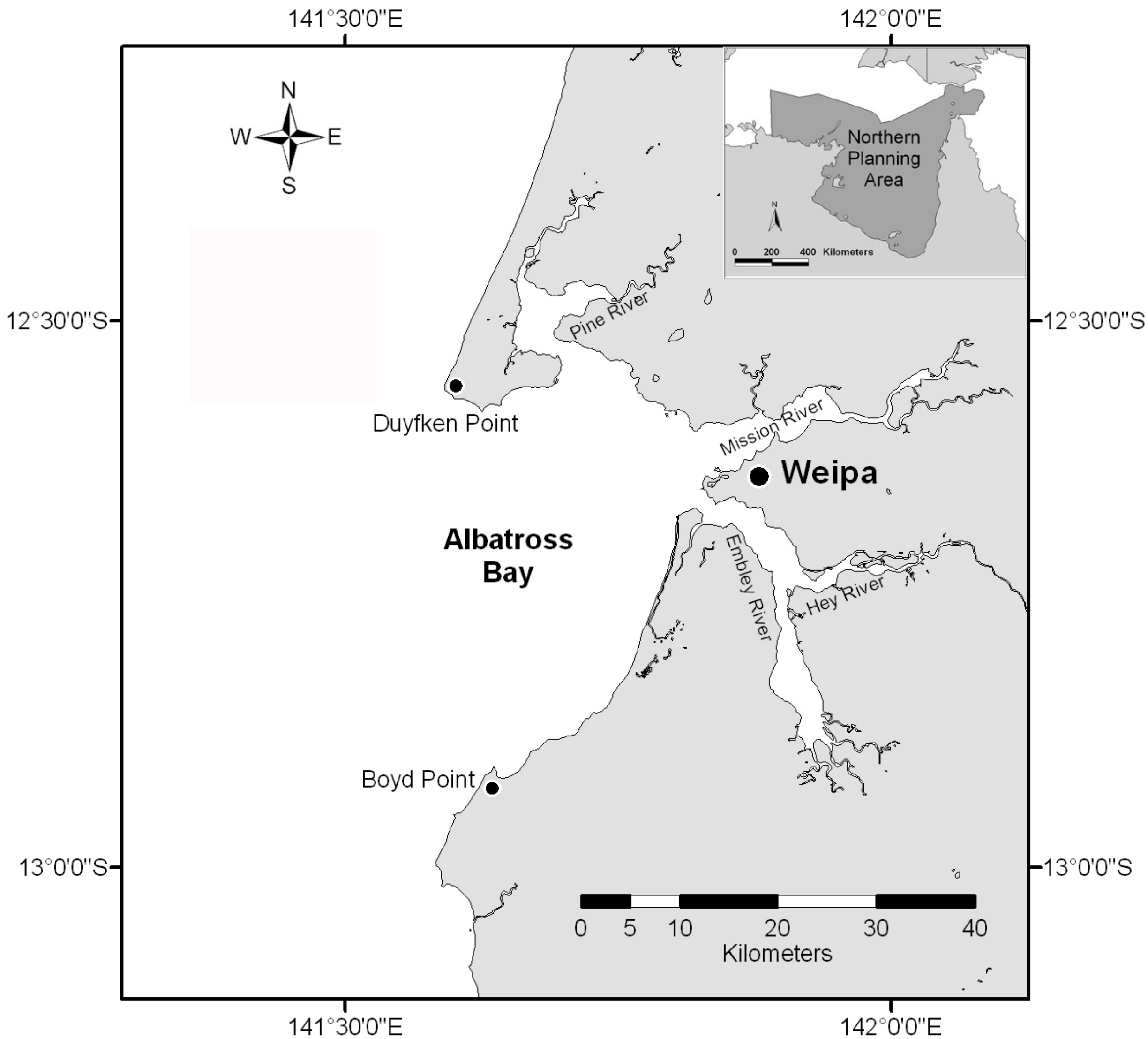

Figure 3. Location of the Weipa study region within the Northern Planning Area (shown in inset). Sampling was conducted throughout Albatross Bay and the adjoining estuaries.

4.2 Collection of specimens

Monthly collections of queenfish were undertaken between 22 April 2004 and 23 May 2005 in the Weipa region, Queensland, Australia in an attempt to capture the temporal variability in their life history characteristics. All fish were captured in Albatross Bay and its adjoining estuaries, namely the Embley, Hey, Mission and Pine rivers (Fig. 3), to prevent confounding effects of possible different growth rates of fish from different regions. Specimens were obtained from local fishing tour operators using hook and line, and commercial fishers and scientific collections using gillnets of various sizes. We also accepted whole fish from recreational fishers in Weipa who wanted to contribute to the project after being informed of the project through a nationwide radio and press release (see Appendices 1 to 4). Fish were put on ice upon capture, frozen on return to shore, and then freighted to the CSIRO Marine and Atmospheric Research laboratories at Cleveland for processing.

In the laboratory, fish were weighed (± 0.1 g), measured for their fork and total length (FL and TL in mm), and sexed by visual examination of the gonads. Only fork length is given in this report unless otherwise stated. Sagittal otolith pairs were removed from each fish by making a horizontal incision from the snout to the operculum origin, removing the brain and accessing the otic capsule. Each otolith was cleaned in distilled water, dried and placed in a small labelled plastic bag. Each otolith was later weighed (± 0.00001 g) on a microbalance to evaluate this measure as a predictor of age. Both gonad lobes were also removed, weighed (± 0.001 g), trimmed of fat and placed in a labelled perforated plastic bag. Gonads were then fixed in a 10% formaldehyde solution for at least 14 days and then stored in 70% ethanol until histological analysis.

4.3 Age and growth

Queenfish were aged by counting the growth bands of sagittal otoliths. One otolith was randomly selected from the pair of otoliths in each fish for ageing. Each otolith was embedded in an epoxy resin block and allowed to cure for 48 hours at 36°C. A 400 µm traverse section of the otolith core was taken from each block using a diamond saw. Each section was then mounted on a separate glass microscope slide with thermoplastic cement and polished with 800-grit wet-dry glasspaper. Immersion oil was applied to the polished surface of the section to improve optical resolution.

Each section was viewed under a light transmitted compound microscope at 100x magnification. We recorded the number of opaque bands along the dorsal axis, as bands were more distinct in this region of the otolith. Otoliths were examined in random order to avoid biases with respect to fish size class. Growth ring counts were made on each otolith on two separate occasions and where these counts differed, a third count was taken. Estimated ages of fish obtained from annuli counts in the otoliths were regressed against otolith weight to assess otolith weight as a predictor of age.

Length-at-age data derived from otoliths was used to estimate growth parameters for the von Bertalanffy growth function (VBGF):

$$L_t = L_\infty (1\text{-}\exp[-K(t\text{-}t_0)]), \qquad (1)$$

where L_t= the fork length of the fish at age t, L_∞= theoretical length at age infinity, K= the intrinsic growth rate, and t_0= the theoretical age at length zero. The parameters L_∞, K and t_0 were calculated using the Excel add-in program "Solver" to minimise the residual sums of squares. Separate models were fitted to males and females and both sexes combined.

Marginal increment analysis was carried out on all sectioned otoliths to validate one translucent and one opaque band as annuli. Analysis was restricted to otoliths aged at two rings due to growth ring interpretation difficulties close to the otolith core in young fish (0+ and age 1) and because samples of larger fish (age 3 and above) were not available for every calendar month. The width of the marginal increment was measured using 'Leica Image Manager' software from the distal edge of the marginal opaque zone and the otolith edge. Once growth bands were validated as annuli, the size of the marginal increment in each otolith was estimated as a proportion of a year and then added to the number of complete growth bands observed to provide a more precise estimate of age.

4.4 Mortality

VBGF parameters and maximum age estimates were used to compare the annual natural mortality rate (M) using three empirical equations:

$$ln(M) = -0.0152 - 0.279\ ln(L_\infty) + 0.6543\ ln(K) + 0.463\ ln(T), \text{ (Pauly 1980)} \qquad (2)$$

where K and L_∞ are derived from the von Bertalanffy growth function and T is the annual mean water temperature estimated at 28° C (CSIRO unpublished sea surface temperature data),

$$M = 1.60\ (K),\ \text{(Jensen 1996)} \qquad (3)$$

where K is the von Bertalanffy growth parameter, and

$$M = -\ln(0.01)/\omega,\ \text{(Hoenig 1983)} \qquad (4)$$

where ω is longevity in years.

Sufficient data was not available to directly measure fishing mortality (F) from commercial or recreational fisheries, although we were able to estimate the total instantaneous mortality rate (Z) of each fishery using age-based catch curves (Beverton & Holt, 1957). Fish numbers within each age class were log transformed and plotted against age classes. Total mortality (Z) was estimated from the slope of a linear regression fitted to the declining part of the age distribution. An estimate of F for each fishery was then made from the equation $F=Z-M$.

4.5 Reproduction

We assessed reproductive activity using two methods; a gonadosomatic index (GSI) and histology. GSI was determined for each fish for both males and females using the equation:

$$GSI = \left(\frac{gonad\ weight\ (g)}{whole\ body\ weight\ (g) - gonad\ weight\ (g)} \right) \times 100 \qquad (5)$$

All immature fish were excluded from our analysis of GSI data to describe peak spawning activity.

Two stages of maturity were estimated using GSI data and histology. Length at first maturity (L_{MAT}) for both males and females was determined by plotting fish length against GSI and the length at which the greatest increase in GSI was observed was deemed the length at first maturity. Length at 50% maturity (L_{50}) was estimated using histology for females only, which is the length at which 50% of females had mature ovaries. Fish were grouped into 50 mm length intervals and the proportion of mature fish in each size class was calculated. The following logistic function was then fitted to the data to determine L_{50}:

$$Proportion\ of\ \ females\ mature = \frac{1}{1 + exp(-K[(fork\ length)\ L_{50}])} \qquad (6)$$

where K is the curvature of the function. The value for L_{50} was then substituted into the VBGF length-at-age function (1) to provide an estimate of age at 50% maturity.

4.5.1 Histology

For histological examination of gonads a subsample of ovary, approximately 1g, was placed in a histological cassette, infiltrated with paraffin, and sectioned at 6μm using a tissue microtome. At least three sections were taken from each gonad and together, were mounted on a glass microscope slide and stained with Harris's haematoxylin and eosin counter stain. Only females were examined by histology due to time and budgetary constraints, but also because i) female ovary development is more indicative of spawning activity, and ii) it is generally only female reproductive parameters that are considered in stock assessment models since female energy investment into reproduction is usually higher than for males (West 1990, King 1995). Ovaries were staged according to the most advance group of oocyte present using the methods of Davis et al. (2002) as: unyolked (stage I), early yolked (stage II), advanced yolked (stage III), migratory nucleus (stage IV), hydrated (stage V) and atresia (stage VI) (see Appendix 5). We initially proposed to quantify reproductive activity using macroscopic examination of gonads, but later elected to undertake histology because of the difficulty in separating spent (stage VI) and resting (stage II) gonads. We herein refer to mature fish as being stage IV-VI. Temporal variation in reproductive activity was examined using GSI and histological data by plotting mean GSIs and the proportion of mature females across months, respectively.

4.5.2 Batch fecundity

Batch fecundity was estimated from ovary subsamples containing unovulated hydrated oocytes (stage IV and V). Subsamples (0.4-0.6 g) were weighed (±0.001 g), oocytes teased apart from connective tissue and the number of hydrated ripe oocytes counted under a stereomicroscope. Fecundity (*F*) and relative fecundity (*RF*) was calculated by the formulas:

$$F = gonad\ weight\,(g)\ x \left(\frac{subsample\, egg\ count}{gonad\ sumbsample\ weight\,(g)} \right) \tag{7}$$

$$RF = \frac{F}{total\ body\ weight\,(g) - gonad\ \ weight\,(g)} \tag{8}$$

Fecundity estimates from all samples were averaged to provide the final estimate for batch fecundity for the species.

4.6 Sex ratio

The sex ratio was calculated by using the number of males and females caught pooled across months for the entire study. A chi square test was used to determine if the sex ratio was significantly different to the expected ratio of 1:1. A Kolmogorov-Smirnov (K-S) test was used to determine statistical differences in length-frequency distributions between sexes.

4.7 Genetic material

A tissue bank for pelagic fish species in northern Australia has been established by CSIRO (see Griffiths et al. 2005) for the purpose of future stock determination using DNA analysis. Queenfish were added to this collection by extracting a small piece of muscle tissue from each fish, placing in a small labelled vial containing a 20 % dimethylsulfoxide (DMSO) solution, and storing in a refrigerator.

5. RESULTS

A total of 327 queenfish were examined ranging from 233 to 921 mm and 0.157 to 8.210 kg. No differences in external morphology between sexes were identified. Males (*n*=165) ranged from 301 to 921 mm and from 0.321 to 7.661 kg, while females (*n*=162) ranged from 233 to 903 mm and 0.157 to 8.210 kg. Four fish (347-354 mm) had immature gonads and were unable to be sexed. Length-frequency distributions of males and females were not significantly different (K-S test Z=0.819; P=0.514; Fig.4). The sex ratio of 1:1.3 was not significantly different from the expected 1:1 (Chi-square=0.09; d.f.=1; P=0.764).

Since fork length-weight and fork length-total length regressions did not differ between sexes (Table 1), data were pooled to provide overall relationships. A power function best fitted the data with 99% of the variation being explained by the curve (Fig. 5). A linear relationship best explained the relationship between fork length and total length explaining 99% of the variation (Fig. 6).

Table 1. Fork length-body weight and fork length-total length relationships for Talang queenfish caught in the Weipa region showing males, females and sexes combined.

Sex	*n*	Relationship	r^2
Male	158	Weight = 5e-05(Fork Length) $^{2.7629}$	0.998
Female	148	Weight = 3e-05(Fork Length) $^{2.8130}$	0.990
Combined	306	Weight = 4e-05(Fork Length) $^{2.7915}$	0.989
Male	157	Total Length = 1.1081(Fork Length) + 16.306	0.996
Female	148	Total Length = 1.1082 (Fork Length) + 14.888	0.997
Combined	305	Total Length = 1.1077 (Fork Length) + 15.731	0.997

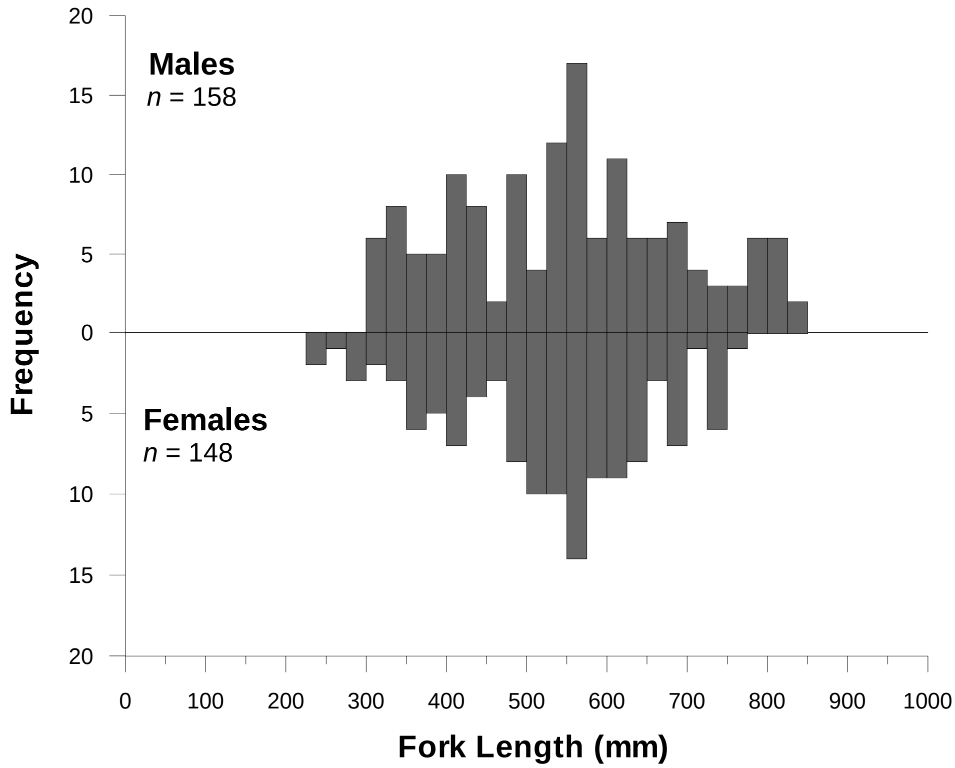

Figure 4. Length-frequency distributions (in 25 mm increments) for male and female queenfish (*Scomberoides commersonnianus*) captured using a range of sampling methods from the Weipa region between 22 April 2004 and 23 May 2005.

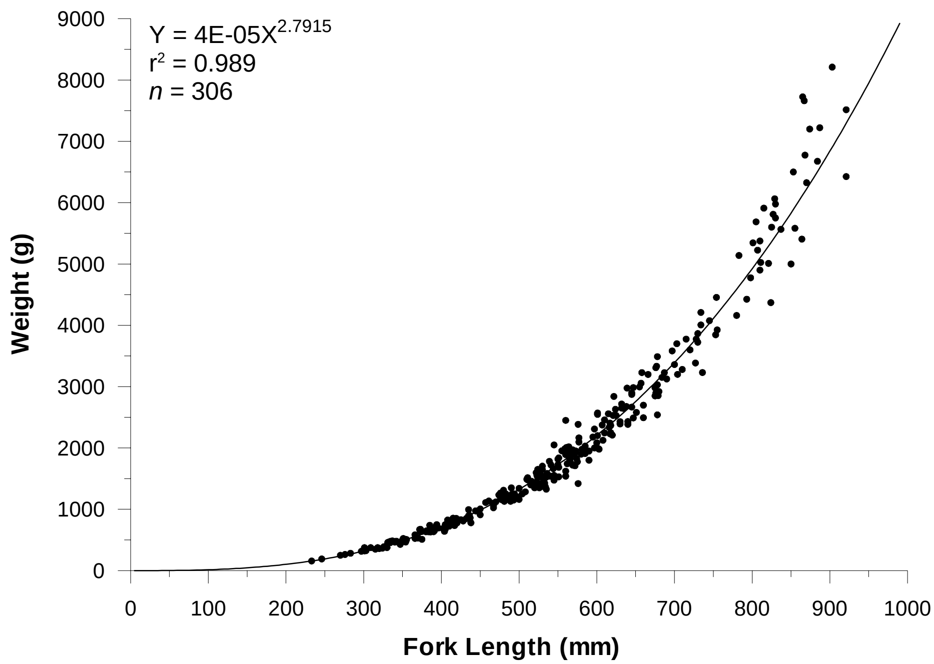

Figure 5. Length-weight relationship for *Scomberoides commersonnianus* in the Weipa region. Data has been combined for both sexes.

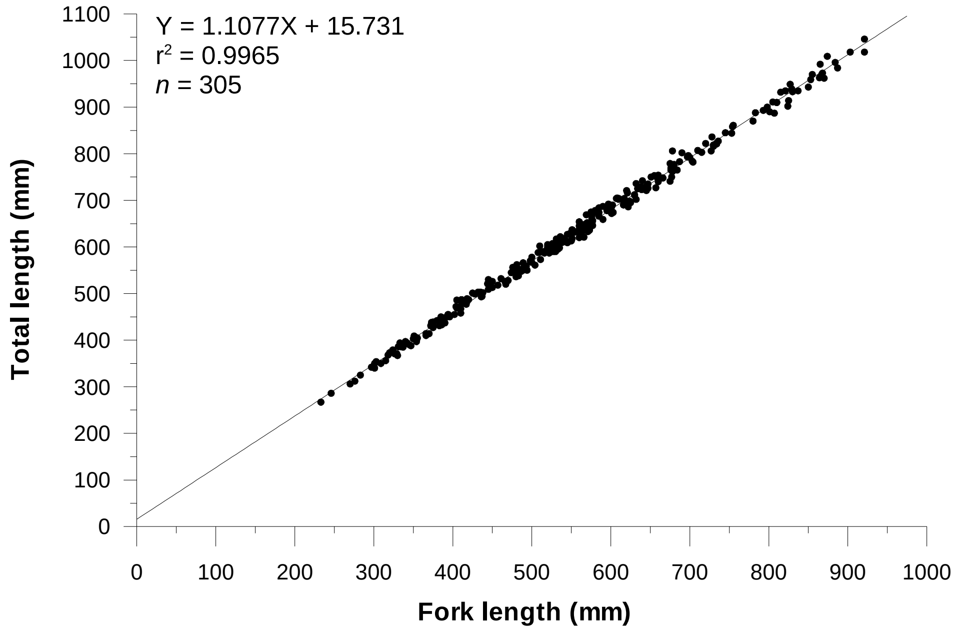

Figure 6. Fork length-total length relationship for *Scomberoides commersonnianus* in the Weipa region. Data has been combined for both sexes.

5.1 Age and growth

Otoliths from 294 queenfish (148 females; 233-921 mm) and (146 males; 233-903 mm) were examined for ageing and marginal increment analysis. When viewed under transmitted light, otoliths showed a pattern of alternating narrow opaque and wider translucent bands. However the banding was not as clearly defined as for many other fish species and daily rings were not clearly visible (Fig. 7).

Mean monthly marginal increment widths in otoliths with two growth rings showed a general increasing trend over the months from September to December and decreasing in the months of January to August (Fig. 8). However, for the months of May, June and October, mean marginal increment widths were relatively high. This may have been a result of poor increment definition in many otoliths coupled with difficulties in interpreting the marginal increments that are nearly complete or just completed. Nonetheless from our results, annual growth rings begin to form between July and August, thus indirectly validating the use of sagittal otoliths as ageing structures.

Estimated VBGF parameters for males, females and sexes combined are given in Table 2. Since growth parameters were similar for males and females age and growth are described as sexes combined. Fish ranged in age from 0+ (no visible first band) to 11 years, but the majority of fish were age 2-4 years (Fig. 9). The oldest female and male fish was 10 and 11 years, respectively. Growth of queenfish is rapid, particularly in the first few years of life, attaining lengths of 245, 379, and 493 mm at ages 1, 2 and 3 years, respectively (Fig. 10). Fish from a wide range of lengths comprised each age class, particularly age 4 where fish ranged in length from 490-820 mm. There was a strong linear relationship between age and otolith weight (r=0.812; Fig. 11). Using our growth curve it is estimated that the age of the largest specimen recorded for the species (1200 mm TL) is 14-15 years.

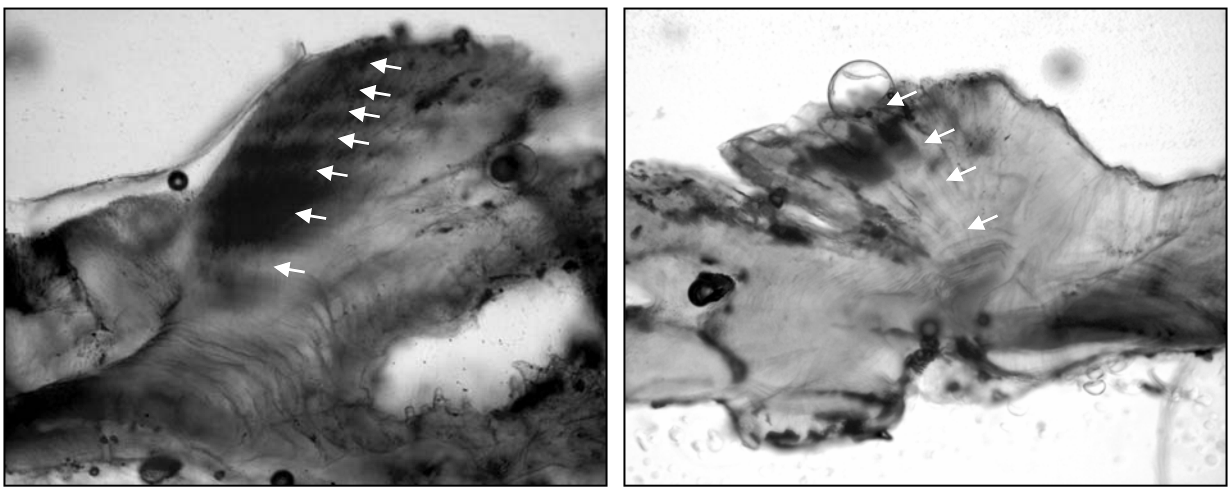

Figure 7. Photographs showing the variation in clarity of opaque growth bands in sectioned otoliths for queenfish, *Scomberoides commersonnianus*. The images show an otolith (from a 703mm FL fish) with relatively well defined annual growth bands (left) and a typical otolith (from a 887 mm FL fish) with poorly defined growth bands (right). Arrows indicate identified opaque growth bands.

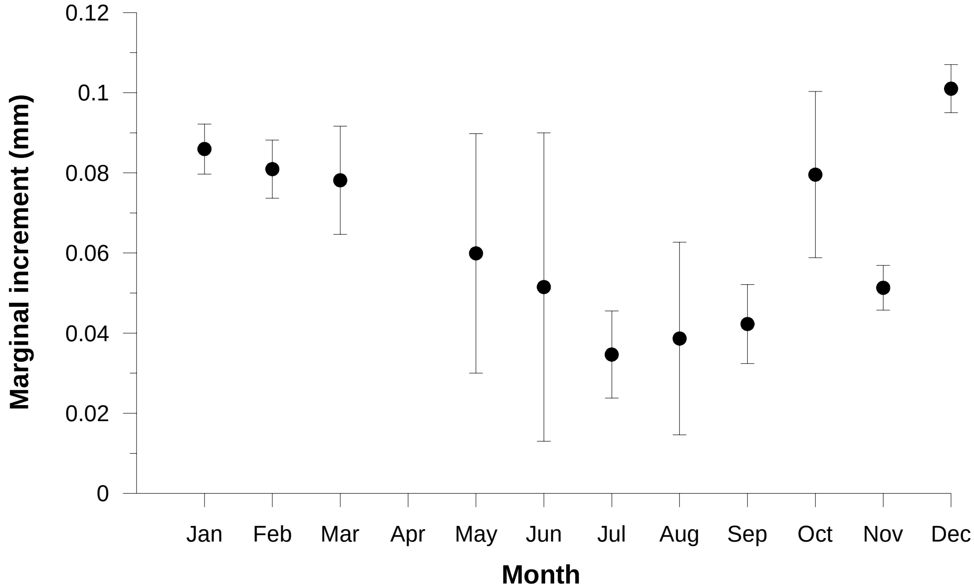

Figure 8. Monthly mean (± s.e.) marginal increments (in mm) for queenfish, *Scomberoides commersonnianus* of age class two.

Table 2. Queenfish fork length-at-age relationships for males, females and sexes combined in the Weipa region.

Sex	*n*	L_∞	*K*	t_0	r^2
Males	146	1136.059	0.161	-0.577	0.811
Females	148	1286.590	0.136	-0.503	0.829
Combined	294	1196.910	0.151	-0.518	0.820

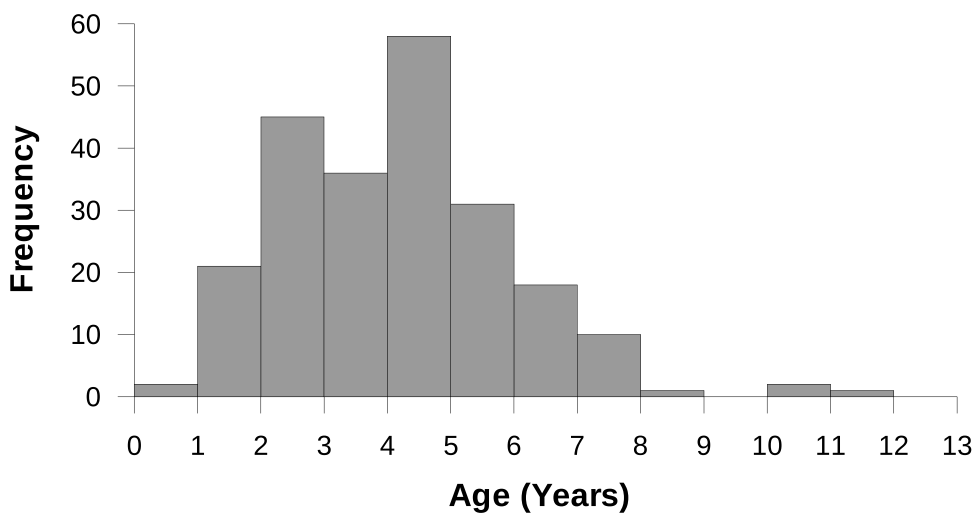

Figure 9. Age-frequency distribution for queenfish, *Scomberoides commersonnianus*, (sexes combined) captured using a range of sampling methods from the Weipa region between 22 April 2004 and 23 May 2005.

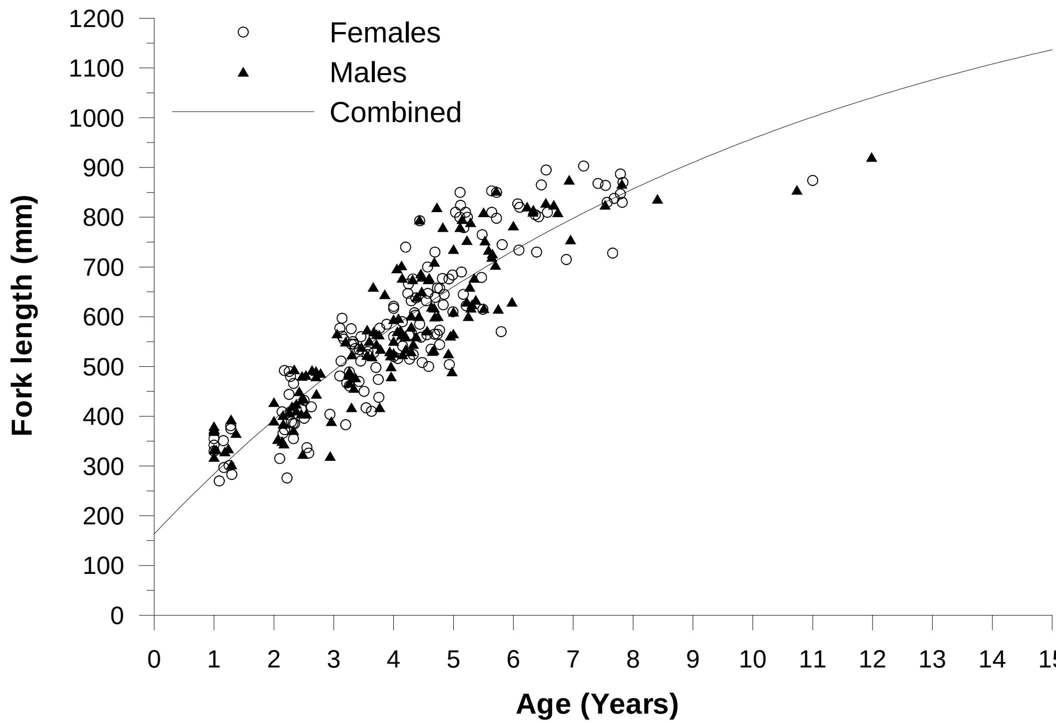

Figure 10. Length-at-age plot for male and female queenfish, *Scomberoides commersonnianus*, showing the von Bertalanffy growth function fitted to age and fork length (mm) data (sexes combined) for fish collected in the Weipa region between 22 April 2004 and 23 May 2005.

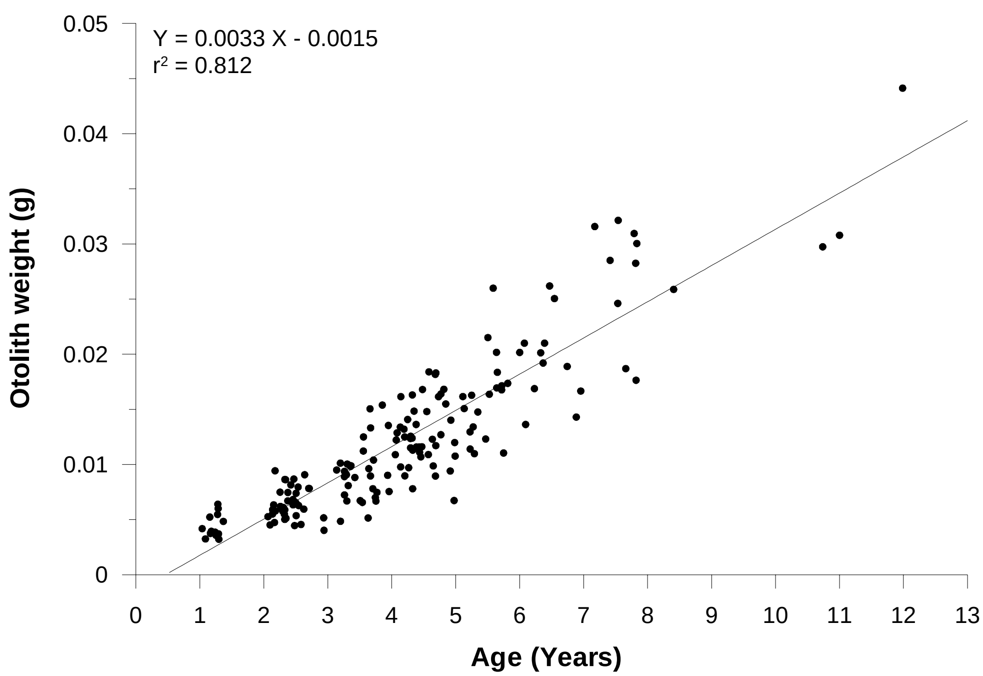

Figure 11. Relationship of otolith weight and estimated age for the Talang queenfish, *Scomberoides commersonnianus*, (sexes combined) captured using a range of sampling methods from the Weipa region between 22 April 2004 and 23 May 2005. Relationship and regression coefficient is shown.

5.2 Mortality

Using the VBGF parameters and maximum estimated age it was possible to estimate the annual natural and total mortality rates of the Weipa population. All three empirical formulas gave slightly different estimates of *M*; 0.341 yr^{-1} (Pauly 1980), 0.242 yr^{-1} (Jensen 1996) and 0.318 yr^{-1} (Hoenig 1983). We were least confident with the value from the method of Hoenig (1983) since we could only estimate maximum age from our growth curve and not measure directly from the otoliths of large fish. The method of Pauly (1980) probably gave the most reasonable estimate of *M* since our estimates of L_∞ and *K* were reliable and the model also incorporates the effect of water temperature on growth and survivorship. Age-based catch curve analysis yielded total mortality estimates of 0.554 yr^{-1} and 0.825 yr^{-1} for recreational and commercial catches of *S. commersonnianus*, respectively (Fig. 12). By subtracting our estimates of *M* from *Z*, the estimated fishing mortality induced by recreational and commercial fishing in the Weipa region is 0.213 yr^{-1} and 0.484 yr^{-1}, respectively.

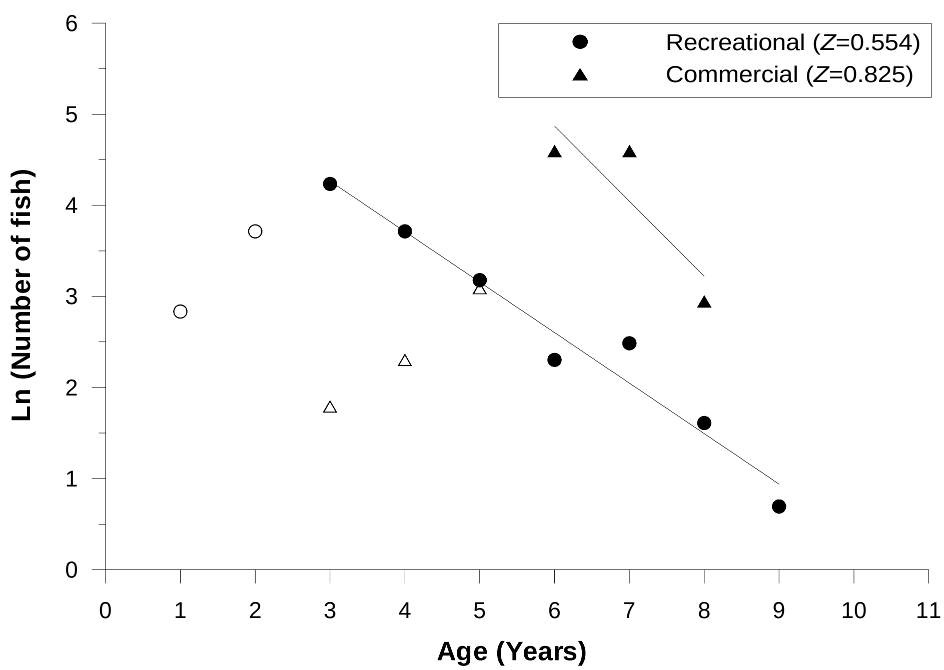

Figure 12. Age-based catch-curves estimating total mortality rates (*Z*) of *S. commersonnianus* from recreational and commercial fisheries in the Weipa region. Hollow data points indicate those which were excluded from the analysis.

5.3 Reproduction

5.3.1 Length and age at maturity

Histology data indicated that the smallest mature female was 476 mm and about 3 years of age. However, the next largest mature fish was 530 mm. Using a logistic function, the size at which 50% of females are mature was estimated as 635.3 mm (Fig. 13). Using the length-at-age growth curve, this translates to an age of 4-5 years or 53% of L_{∞}. The estimate of L_{mat} for females using GSIs was identical to histology being 476 mm. GSI data revealed males reach L_{mat} slightly earlier than females at 385 mm and 2-3 years (Fig. 14). An estimate L_{50} for males was not possible since male gonads were not examined by histology.

5.3.2 Spawning season

GSIs were calculated for 327 male and female fish, whereas histology was undertaken on 131 fish representing females only. Mean monthly GSIs reveal that queenfish have a protracted spawning season between September and March, which coincides with the wet season, and display lowest reproductive activity in the dry season between April and August (Fig. 15). From our data, gonad development during the spawning period may be interpreted as two separate peaks in spawning activity; in November and February. However, this is probably an artefact of small sample sizes in December (n=13) and the actual trend is likely to be a general increase gonad development from September to the major peak in February where females had an average GSI of 1.52 % (± 0.43). GSI values for mature queenfish were relatively low in comparison to what is expected from other carangids. Of all the females with highly developed ovaries (stage IV-V) only four fish had a GSI above 2% of body weight.

Results of histology were analogous with GSI data in that fish with highly developed (stage IV-V) or spent (stage VI) ovaries were recorded between August and February. Histology also confirmed two main spawning peaks; in November and February, where 100% of females were stage IV or V (Fig. 16). In agreement with GSI data, there was no spawning activity in December, but this is probably due to the capture of only six small females (438-580 mm) during this period, which were probably immature. The gonads of these fish were stage II-III with no evidence of scar tissue, indicating they were unlikely to have spawned previously.

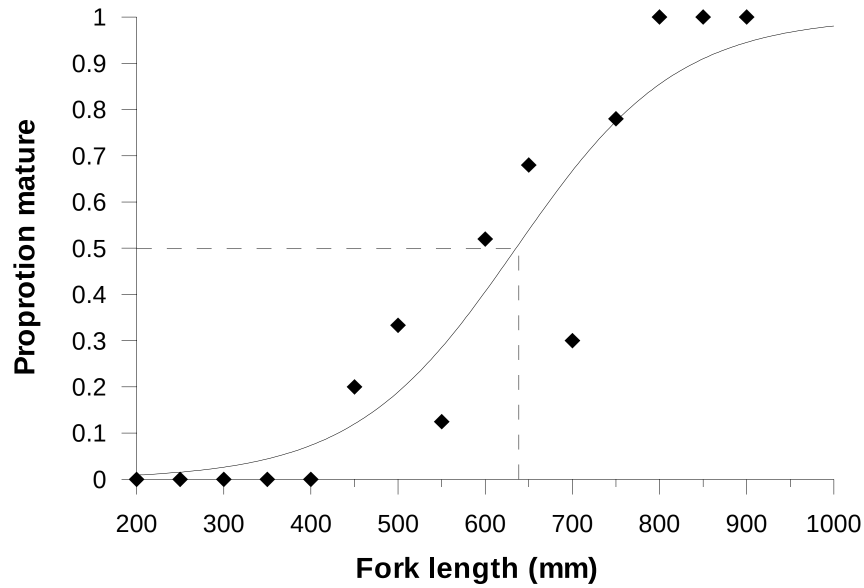

Figure 13. Proportion of mature female Talang queenfish in each 50 mm size interval captured during the spawning season (September 2004-March 2005). The trendline is logistic curve fitted to the data. Dashed line indicates the length at which 50% of fish are considered mature (L_{50}) as determined by histology.

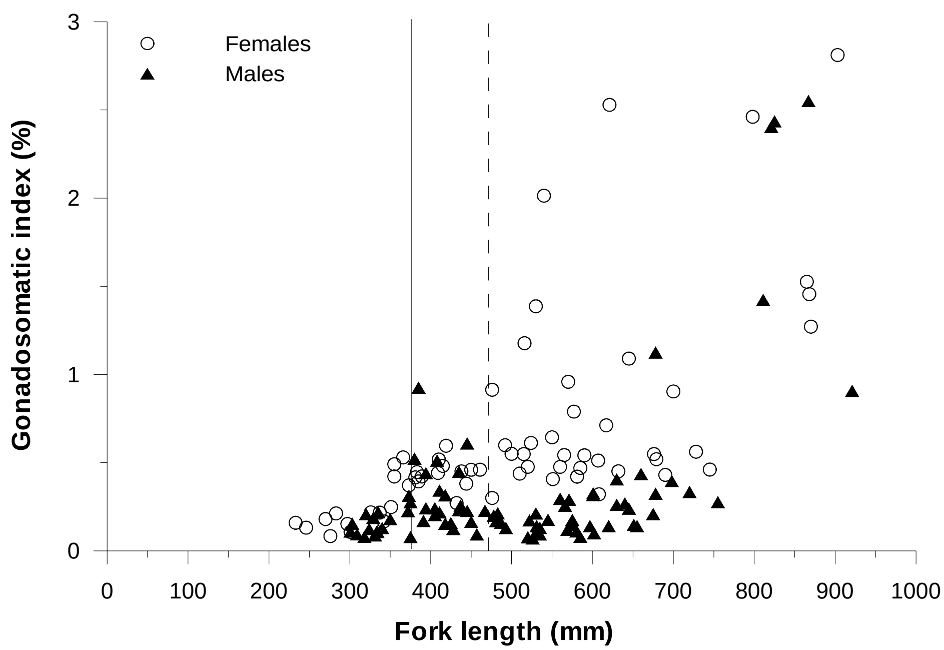

Figure 14. Plot of gonadosomatic index and fork length (mm) for male and female Talang queenfish, *Scomberoides commersonnianus*, collected in the Weipa region between 22 April 2004 and 23 May 2005. Solid and dashed lines indicate estimated length-at-first maturity (L_{MAT}) for males and females, respectively.

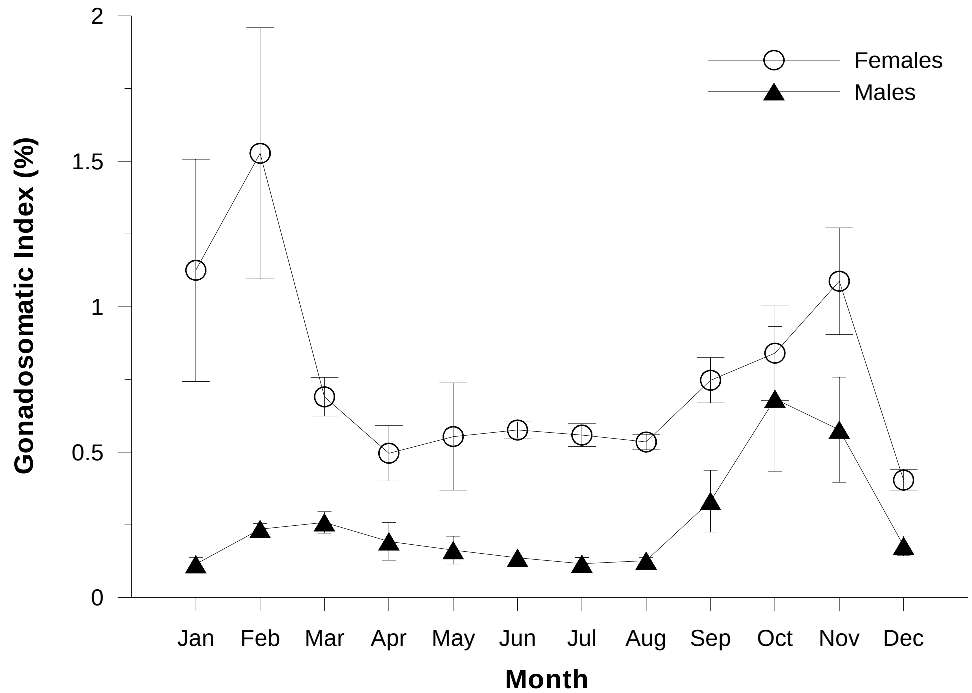

Figure 15. Mean (± s.e.) monthly gonadosomatic index values for male and female Talang queenfish, *Scomberoides commersonnianus*, collected in the Weipa region between 22 April 2004 and 23 May 2005. Immature fish have been excluded.

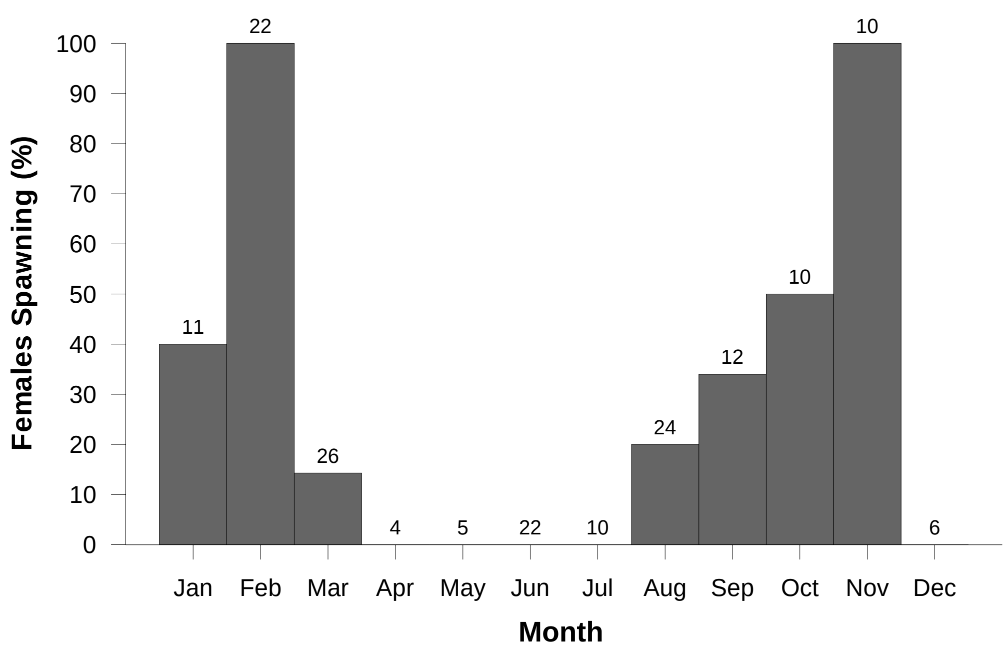

Figure 16. Monthly percentages of female Talang queenfish spawning (histological stages IV-VI) in the Weipa region between 22 April 2004 and 23 May 2005. Numbers above bars show the sample size.

5.3.3 Batch Fecundity

A total of 15 female gonads were suitable to assess batch fecundity. The total number of eggs produced by individual fish ranged between 259,488 and 2,859,935 eggs with an average batch fecundity of 1,327,827 (± s.e. 237,866) eggs. There was a strong positive relationship between the total number of eggs produced versus fork length (r=0.94; Fig. 17) and ovary-free body weight (r=0.93; Fig. 18).

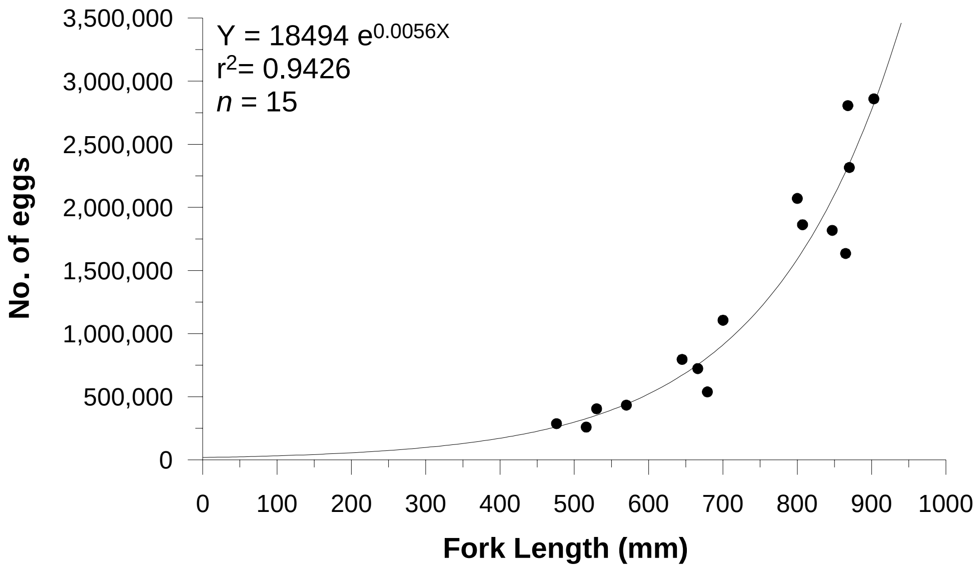

Figure 17. Relationship between batch fecundity and fork length (mm) for female Talang queenfish from the Weipa region. Only fish with gonads of late stage IV and V were examined.

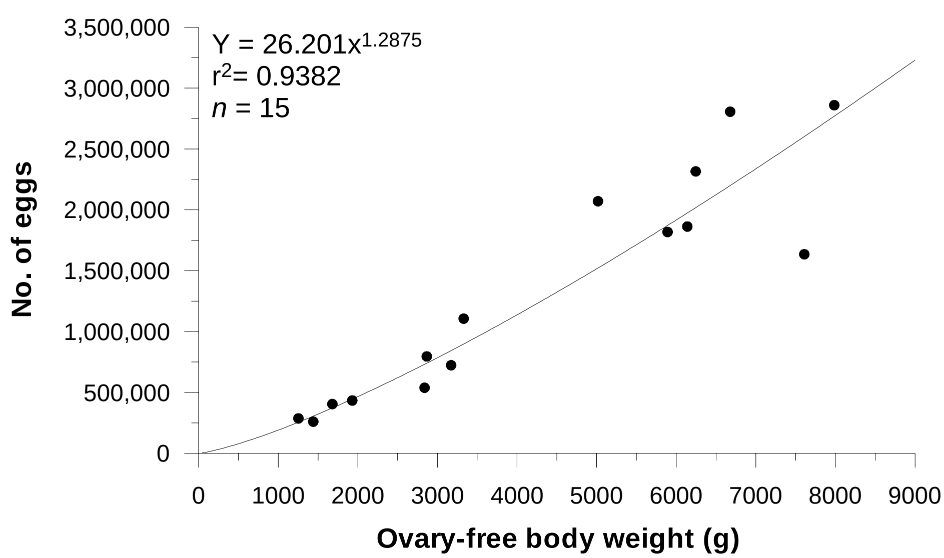

Figure 18. Relationship between batch fecundity and ovary-free body weight (g) for female Talang queenfish from the Weipa region. Only fish with gonads of late stage IV and V were examined.

6. DISCUSSION

Queenfish are one of northern Australia's most important predatory species of inshore and estuarine habitats. Not only are they ecologically important owing to their abundance, relatively large size and voracious feeding behaviour, but they are also of great importance to recreational fisheries and fishing tour operators, and appear to be of growing importance to commercial fisheries in northern Australia. Their neritic distribution and apparent use of estuaries as nursery habitats may contribute to the populations of this species being vulnerable to becoming unsustainable if not managed properly. This is the first study to investigate the life history of *S. commersonnianus* in Australia, and has provided critical information that can be used by fisheries managers to make informed decisions regarding the sustainable exploitation of queenfish, not only as a target species but often as a significant bycatch of recreational and commercial fisheries for other target species, such as barramundi.

6.1 Age, growth and mortality

We were successful in ageing queenfish using sagittal otoliths, which has been problematic for other tropical carangids. Grandcourt et al. (2004) found an absence of alternating translucent and opaque bands that could be interpreted as annuli in the sagittal otoliths of two tropical carangids *Gnathanodon speciosus* and *Carangoides bajad*. Although the clarity of bands in the otoliths of *S. commersonnianus* was far from ideal, results from marginal increment analysis suggested that opaque growth bands in otoliths were formed annually between July and August.

It is apparent from our data that *S. commersonnianus* grow relatively quickly early in life reaching 245, 379, and 493 mm by age 1, 2 and 3 years, respectively and live for at least 11 years. We were unable to obtain exceptionally large specimens (10+ kg) and our largest specimen was 8.2 kg. However, there are several instances of queenfish reaching the maximum recorded weight of 16 kg in northern Australia (ANSA 2005, IGFA 2005). Using our growth curve, it is estimated that a 16 kg fish may be around 14-15 years of age.

Since no previous studies have investigated the age and growth of *S. commersonnianus*, or any other species in the genus, we are unable to make any directs comparisons with our results.

However, the growth rate of *S. commersonnianus* is very different with what has been observed for similar sized Carangids from other tropical regions. In the Southern Arabian Gulf, Grandcourt et al. (2004) found *G. speciosus* and *C. bajad* to both grow quickly attaining lengths corresponding to 85% of L_∞ by age 3 years. In contrast, *S. commersonnianus* attain a length corresponding to 85% of L_∞ at age 12 years. Similarly, the natural mortality rate of *S. commersonnianus* (M=0.341 yr^{-1}) is also considerably lower than the estimates made by Grandcourt et al. (2004) for *G. speciosus* (M=0.822 yr^{-1}) and *C. bajad* (M=0.957 yr^{-1}) using the methods of Pauly (1980).

The growth of *S. commersonnianus* appears more comparable to a slower growing carangid species of temperate Australia, the silver trevally (*Pseudocaranx dentex*). Rowling and Raines (2000) also studied *P. dentex* in New South Wales (NSW) and found they were slow-growing and relatively long-lived with the oldest fish being aged at 24 years. Kalish and Johnston (1997) also studied the age and growth of *P. dentex* in New South Wales waters and found they reach 85% of L_∞ at age 13 years. From their VBGF parameters and assuming an annual water temperature of 20° C, we estimate the natural mortality rate *P. dentex* is remarkably similar (M=0.351 yr^{-1}) to *S. commersonnianus*.

6.2 Reproductive dynamics

Talang queenfish appear to reach first maturity relatively early in life at around age 3 years and 475 mm, although this maybe an extreme outlier since the next smallest mature female was 530 mm. Considering the great variability in the length at which fish first attain maturity, it is usually more acceptable to use an estimate of L_{50} for determining length at maturity. Our estimate of L_{50} suggests that *S. commersonnianus* reach maturity relatively late in life at age 4-5 years and 634 mm, or approximately 53% of L_∞. This estimate is higher than a similar sized tropical Carangid, *G. speciosus*, which attains L_{50} earlier in life at about 45% of L_∞. However, the length at maturity of *S. commersonnianus* is even greater in comparison to *P. dentex* in temperate NSW waters, which attain L_{50} at approximately 30% of L_∞, or 4-5 years (Rowling & Raines, 2000).

It is important to note that despite the good fit of the logistic curve to our histological data to determine L_{50}, it was unfortunate that some months during the peak spawning season, namely December, yielded the least amount of data. This was due to the spawning season coinciding with seasonal closures in the Queensland N3 fishery and a general “shut down” period for fishing tour operators in Weipa due to the wet season, and as a result, samples were difficult to obtain. Although we feel our estimate of L_{50} is robust, we suggest that any future study on the reproductive dynamics of queenfish in northern Australia should concentrate on collecting specimens during this spawning month, which may help confirm or improve on our estimate of L_{50}.

Interestingly, it was noted by line fishers collecting our specimens that queenfish are also significantly more difficult to catch during the spawning period. This may be a result of fish moving away from the area to spawn or just being shy to baits and lures during the spawning season. However, there is evidence to suggest that queenfish may spawn in offshore waters. We undertook an opportunistic sampling trip during February 2005 for a related project on pelagic fishes (Griffiths et al. 2005) onboard a commercial fishing vessel operating in Queensland's N9 offshore gillnet fishery approximately 7-10 nm from Duyfken Point (Fig. 3). Here we found a small number of large fish (>853 mm) with ripe running eggs, indicating they were in fact spawning in this offshore region. Blaber et al. (1989) found *S. commersonnianus* to dramatically increase in abundance in the lower reaches of the Embley estuary during February over two consecutive years. It is plausible that these high catches indicate that fish may move to the lower reaches of the estuary en route to spawning areas further offshore during February.

There is also some limited tagging data suggesting that fish may move from the Embley estuary during the wet season around February (SUNTAG, unpublished data). A fish was tagged during early February in the Embley estuary and was recaptured 43 days later 6 km downstream outside the estuary mouth (Wooldrum Point). Four other fish recaptured outside the peak spawning period in May and September in the estuaries around Weipa (Hey, Pine and Mission Rivers) showed no movement from the area in which they were tagged.

Talang queenfish also appear to have similar fecundity as *P. dentex* from New South Wales. Kalish and Johnston (1997) estimated *P. dentex* to produce 2-5 million eggs which is similar to our average batch fecundity estimate of 1,327,827 eggs for *S. commersonnianus*. Rowling and Raines (2000) also estimated batch fecundity of *P. dentex* from New South Wales and estimated females to produce less than 220,000 eggs. However, their fecundity estimate was derived from stage IV fish only, as they were unable to obtain samples of ripe (stage V) females.

6.3 Implications for management

The similarity of life history characteristics and increasing exploitation of *S. commersonnianus* and *P. dentex* suggest that more conservative management actions be implemented for *S. commersonnianus* in northern Australia, in a similar vein as to what has been suggested for NSW. Previous to the study of Rowling and Raines (2000) there was no minimum legal length (MLL) for *P. dentex* for commercial or recreational fisheries in NSW, since it was assumed they had similar life histories to other well studied pelagic fishes being fast growing and "extremely fecund" (Rowling & Raines 2000). Due to the increasing commercial and recreational catch of silver trevally in NSW state fisheries, and a steady decline in the commercial catch in the South East Trawl fishery, a MLL has since been suggested as a measure to protect immature fish from being taken (Rowling & Raines 2000).

Currently in state and commonwealth waters within the NPA there is no MLL on *S. commersonnianus* for commercial or recreational fisheries, except for the Gulf of Carpentaria where a MLL of 45 cm TL exists. These regulations may have been a result of the perceived high abundance of queenfish and historically low commercial fishing pressure throughout northern Australia and the presumption that carangids are highly productive and reach maturity early in life. Our results suggest that queenfish may not mature as early as generally assumed and that even the current MLL of 45 cm TL imposed in the Gulf of Carpentaria may be inadequate to protect immature fish. In light of the increasing importance of queenfish to commercial and recreational fishers in northern Australia we recommend the establishment of a MLL size throughout its range, or at least in the NPA. Based on our histological results we recommend an increase in the MLL equivalent to our L_{50} estimate of 64 cm FL (72 cm TL) in order to ensure immature fish are not taken.

7. RECOMMENDATIONS

This project has reported on important information regarding the current status of fisheries for queenfishes (*Scomberoides* spp.) by commercial and recreational fishers in northern Australia, and has produced the first information on the age, growth, mortality and reproductive dynamics of *S. commersonnianus* in Australia. By undertaking this study we have revealed a range of interesting and important questions which may further help improve our knowledge of the species and to better guide future management. Below we have made a number of recommendations from this study and suggestions for future work.

- Investigate the genetic stock structure of queenfish throughout its Australian distribution to identify genetically distinct stocks, which may be used to guide future management directions.

- Undertake similar life history research in other areas throughout the distribution of *S. commersonnianus*, or at least the NPA, to determine whether life history characteristics vary spatially.

- Undertake further sampling in offshore regions during the spawning season in order to identify specific spawning locations.

- Make a recommendation to state fisheries agencies that if current trends in increasing catches continue, a minimum legal length be established and the existing MLL in the Gulf of Carpentaria be increased to at least 72 cm TL.

- Undertake a preliminary stock assessment to determine the exploitation status of queenfish in the NPA.

- Undertake research on the post-capture survival of queenfish by FTOs and recreational fishers in order to better estimate the mortality rate of the large proportion of the catch that is reported to be released.

8. OBJECTIVES MET

✓ **Estimate length-at-age and growth rates of the Talang queenfish using sagittal otoliths, with age validation using marginal increment analysis**

Queenfish grow relatively quickly early in life attaining 245, 379, and 493 mm FL by age 1, 2 and 3 years, respectively. However, their growth rate is slower than other tropical carangids and is more comparable to a temperate species, *Pseudocaranx dentex*. Marginal increment analysis indirectly validated that opaque growth bands in sagittal otoliths were formed annually during July and August.

✓ **Investigate the reproductive dynamics of queenfish, including:**

b. **Timing of spawning, determined by a gonadosomatic index and histology**

c. **Age and length at maturity**

d. **Reproductive potential by quantifying batch fecundity of mature females**

Both gonadosomatic index data and histology indicate that queenfish in the Weipa region have a protracted spawning season between September and March. Histology revealed that female queenfish attained sexual maturity (L_{50}) at 634 mm FL and age 4-5 years. Mature females were estimated to produce an average of 1,327,827 (± s.e. 237,866) eggs.

✓ **Provide a fork length-weight relationship**

There was no difference in the fork length-weight relationship between male and female queenfish. The overall relationship is: Body weight (g) = 4e-05 (Fork length in mm)$^{2.7915}$

✓ **Collect tissue samples for inclusion in a genetic tissue bank, which will be available for use in future studies aiming to determine the genetic stock structure of queenfish.**

A total of 176 genetic samples were collected from queenfish in the Weipa region and are currently stored in a genetic tissue bank for pelagic fish at CSIRO Marine and Atmospheric Research laboratories at Cleveland, Qld.

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APPENDICES

Appendix 1. The project's press release as it appears on the CSIRO Marine and Atmospheric Research website (www.marine.csiro.au/media/05releases/13jan05.html). The press release was also published in several national and regional newspapers, fishing magazines and internet sites.

Media & Information : **Media Releases**

Study targets queen of northern seas

Date: 13 January 2005

Photo: Dave Donald Sportfishing

The secret life of one of northern Australia's most popular sportfish, the spectacular queenfish, is being studied by CSIRO scientists for clues to its role and abundance in the marine ecosystem.

The year-long study, co-funded by the National Oceans Office, is collecting more than 30 specimens a month from the Gulf of Carpentaria near Weipa where queenfish are caught by recreational anglers and inshore net fisheries.

Results of the study will improve the ability of fisheries managers to sustain queenfish populations into the future.

CSIRO marine biologist Dr Shane Griffiths says queenfish are a major predator of commercially important prawns in the Northern Prawn Fishery, particularly in the Weipa region.

Despite their prominence in estuarine and nearshore food webs little is known about the life cycle of queenfish.

"By examining the gonads of queenfish specimens we hope to determine when they spawn, their age at sexual maturity, and the number of eggs produced by mature females," Dr Griffiths says.

"The number of annual growth bands in their otoliths (earbones) will give us clues to their ages and growth rates.

"This information will shed light on how the natural population fluctuates, and how they might respond to certain levels of fishing, either as a target or bycatch species."

Dave Donald of Dave Donald Sportfishing Charters at Weipa, says queenfish are favoured by anglers for their size, good looks and athleticism.

"They grow to more than a metre in length and can weigh up to 16 kilograms," Mr Donald says.

"They are bright silver and are strong fighters on a line, making spectacular jumps when hooked.

"This important research will provide the first account of what make this species tick."

National Oceans Office planning manager, Rowan Wylie, says information gathered during the project will contribute to the Australian Government's regional marine plan for northern waters between Torres Strait and the eastern Arafura Sea, including the Gulf of Carpentaria.

"Sustainable management of our oceans relies on the best possible information and this project will provide answers on an important species that has received comparatively little scientific attention," Mr Wylie says.

The queenfish specimens are being collected and sent to the CSIRO Marine Laboratories in Brisbane with the help of Dave Donald Sportfishing Charters, Weipa Sportfishing Club and local commercial fishers.

This study is part of ongoing research in support of the Northern Prawn Fishery and its ecosystem, which has been the focus of CSIRO investigations in the region for more than 40 years.

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CSIRO

MARINE RESEARCH

Appendix 2. An example of the project's initial press release published in one of many national and regional newspapers.

Queenfish research

The secret life of one of northern Australia's most popular sportfish, the spectacular queenfish, is being studied by CSIRO scientists for clues to its role and abundance in the marine ecosystem.

The year-long study, co-funded by the National Oceans Office, is collecting more than 30 specimens a month from the Gulf of Carpentaria near Weipa where queenfish are caught by recreational anglers and inshore net fisheries.

Results of the study will improve the ability of fisheries managers to sustain queenfish populations into the future.

CSIRO marine biologist Shane Griffiths says queenfish are a major predator of commercially important prawns in the Northern Prawn Fishery.

Despite their prominence in estuarine and near-shore food webs little is known about the fish's life cycle.

"By examining the gonads of queenfish specimens we hope to determine when they spawn, their age at sexual maturity, and the number of eggs produced by mature females," Dr Griffiths says.

"The number of annual growth bands in their otoliths (earbones) will give us clues to their ages and growth rates.

"This information will shed light on how the natural population fluctuates, and how they might respond to certain levels of fishing, either as a target or bycatch species."

Dave Donald, of Dave Donald Sportfishing Charters at Weipa, says queenfish are favoured by anglers for their size and athleticism.

"They grow to more than 1m in length and can weigh up to 16kg," Mr Donald said.

"This important research will provide the first account of what make this species tick."

National Oceans Office planning manager, Rowan Wylie, says information gathered during the project will contribute to the Australian Government's regional marine plan for northern waters between Torres Strait and the eastern Arafura Sea, including the Gulf of Carpentaria.

Queenfish, rated by US angler Ray Montoya among his fly fishing favourites, are the subject of a CSIRO study.
Picture courtesy Dave Donald Sportfishing.

Appendix 3. An example of the project's initial press release published in one of many national and regional newspapers.

The secret life of queenies studied

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Results of the study will improve the ability of fisheries managers to sustain queenfish populations into the future.

CSIRO marine biologist, Dr Shane Griffiths said queenfish were a major predator of prawns in the northern prawn fishery, particularly in the Weipa region and throughout the gulf.

Despite their prominence in estuarine and nearshore food webs, little is known about the life cycle of queenfish.

"By examining the gonads of queenfish specimens, we hope to determine when they spawn, their age at sexual maturity, and the number of eggs produced by mature females," Dr Griffiths said.

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The queenfish specimens are being collected and sent to the CSIRO marine laboratories in Brisbane with the help of Dave Donald Sportfishing Charters, Weipa Sportfishing Club and local commercial fishers.

This study is part of ongoing research in support of the northern prawn fishery and its ecosystem, which has been the focus of CSIRO investigations in the region for more than 40 years and continues to provide vital information on the marine life in the northern tropical waters.

Appendix 4. An article published in a local Weipa newspaper, “The Weipa Bulletin” (Edition 1910, 30 July 2004), promoting the involvement of Weipa Sportfishing club in the collection of queenfish and other pelagic fishes for the current and related CSIRO projects.

32 *The Weipa Bulletin* *Friday July 30, 2004*

Weipa Sportsfishing club helps CSIRO to gain a better understanding of marine food webs

Weipa Sportfishing Club is assisting CSIRO in it’s endeavours to gain a better understanding of the marine food webs in this region. Very little is known about the pelagic species that feed in the waters of northern Australia.

The Club has dedicated its monthly comps to target and weigh-in ‘research’ species only. Members will only be targeting Cobia, Golden Trevally, Long Tail Tuna, Mack Tuna, Queenfish, Finny Scad and Watson’s Leaping Bonito.

A total of five fish of any combination of the listed species will be eligible. The fish will all be weighed fresh, whole, then tagged and frozen. In the Brisbane laboratories the researchers will later collect stomach contents, otoliths, and gonads and collate information on food sources, maturity and productivity.

CSIRO has made available awards to Club members making significant contributions to the research program. The Club will also allocate points for the captures, that will go towards overall Club Championships awards set down for December. New members are encouraged to become part of this special event for the Club contributing to valuable CSIRO research.

Please phone Club President Peter McCulkin for details. The next Club comp is being run over the weekend of 7th-8th August, with allowances for times and dates as they relate to the Comalco shifts. The BBQ and weigh-in is at the Head residence 13 Pinaroo Court.

Central Cluster

Round 11

Lockhart V Aurukun

(Aurukun at home)

Coen V Napranum Bulldogs

(Bulldogs at home)

Bye: Weipa Tigers.

Weipa Swimming Club

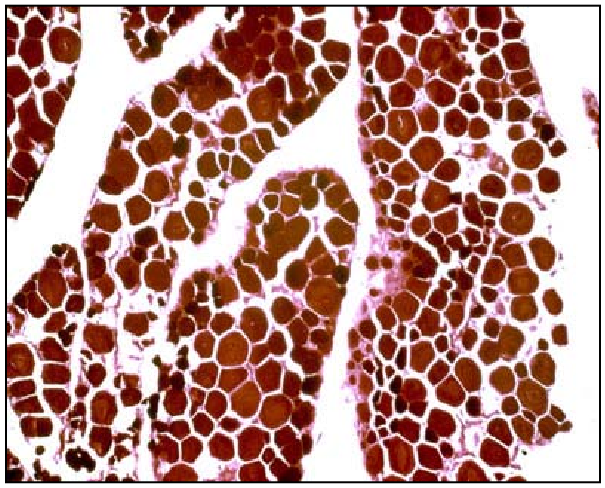
Following a lack of numbers last Sunday (25th) the AGM will now be held on SUNDAY 1ST AUGUST at 5pm at the Pool. Please show your support for the club and come along. In accordance with our Constitution we are required to have nine (9) in attendance, as with all clubs – NO COMMITTEE – NO CLUB!The AGM will be followed by a General Meeting, with items for discussion including – Start Dates for the 2004-2005 Season, Fee Structure, Monthly meeting dates, time and venue.

Cooktown Carnival The carnival will be held on the first weekend of the September/October school holidays, 18th and 19th September. It would be great to see a strong representation from Weipa as the Cooktown swimmers have always made the effort to travel to Weipa. Those interested in attending please contact Barry Murray on 4069 7884 as soon as possible.

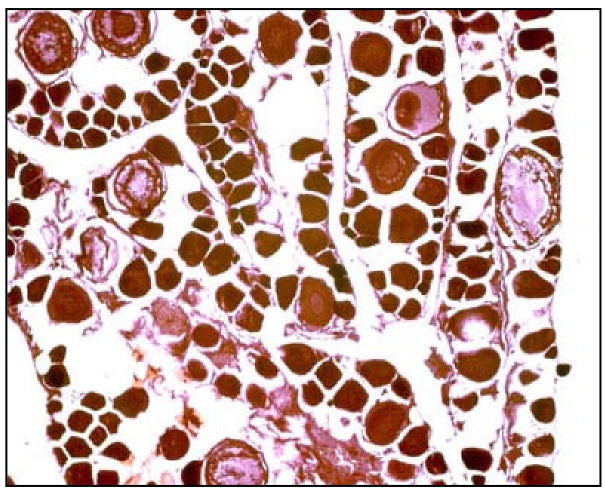
Swim Camp Also in the September/October holidays the “Australian Swim Camps 2004” will be held at venues across Brisbane and Toowoomba. The camp features internationally known coaches, goal setting and relaxation sessions, video taping of each swimmer in every stroke, dryland, nutritional and sport psychology sessions, personal stroke analysis critique booklet, 1:6 coach to swimmer ratio and much more. Please contact Weipa Swimming Club President Barry Murray on 4069 7884 or Secretary Ngaire Baker on 4069 9513 for an application form. The cost is $395

Appendix 5. Histological sections of three stages of female gonads from Talang queenfish showing: 1) unyolked (stage I), 2) early yolked (stage II-III), and 3) hydrated (stage IV).

1)



2)



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