Southern Fisheries Centre Deception Bay QI02100

The status of Queensland's Moreton Bay Bug (*Thenus* spp.) and Balmain Bug (*Ibacus* spp.) stocks

A. J. Courtney

Agency for Food and Fibre Sciences

Queensland Government
Department of Primary Industries

Information Series QI02100

The status of Queensland's Moreton Bay Bug (*Thenus* spp.) and Balmain Bug (*Ibacus* spp.) stocks

A. J. Courtney

November 2002

Agency for Food and Fibre Sciences

QI02100
ISSN 0727-6273
Agdex 486/06

Manager, Publication Production
Department of Primary Industries
GPO Box 46
Brisbane Qld 4001

Executive Summary

This report reviews the trawl logbook trends for the catch and effort statistics of Moreton Bay Bugs in Queensland from 1988-2001 and presents per-recruit analyses on the size at which yield and value of the Bug stocks could be maximised.

Moreton Bay Bugs of the genus *Thenus* spp. (*Thenus orientalis* and *T. indicus*) account for about 80% of Bug landings and value in Queensland with the remaining 20% from Balmain Bugs of the genus *Ibacus* spp. (also includes species known locally as Garlic Bugs and Honey Bugs). While some of the key population parameters, particularly growth and mortality rates, have been quantified for *Thenus* spp., very little research has been undertaken on *Ibacus* spp. in Queensland. The modelling and analyses have therefore focused on *Thenus* spp.

While total reported landings of Bugs in Queensland have declined significantly over the past five years, there is no evidence of a decline in catch per unit effort (CPUE) in the major areas off Townsville and Gladstone. The decline in landings appears largely due to reductions in fishing effort. Logbook data indicate that reported landings of Bugs peaked at 755 tonnes in 1997 and declined to a minimum of 386 tonnes in 2001, representing a $4.5 million reduction in landed value (from $9.06 million in 1997 to $4.6 million in 2001).

The introduction of bycatch reduction devices (BRDs), particularly turtle excluder devices (TEDs) in recent years may have affected landings and catch rates, but this needs to be verified. The current FRDC funded project on trawl bycatch and BRDs (FRDC#2000/170) is examining the effect of various BRDs on the catch rates of prawns, scallops, byproduct (including Bugs) and bycatch.

Information on the growth and mortality rates of *Thenus* spp. were obtained from an FRDC funded tagging project in the mid 1990s (FRDC#92/102). Yield and value per recruit analyses were undertaken on *T. orientalis* and *T. indicus*, based on these data. Collectively the analyses suggest that the current minimum legal size (MLS) of 75 mm CW applied to both species is likely to result in sub-optimal landed value. The precise optimum MLS for all four groups (two species by two sexes) is unknown, but a significant increase in value per recruit could be achieved by increasing the MLS to 80 mm CW. This would also increase the number of eggs produced by the Bug populations and may also reduce the risk of recruitment overfishing.

The status of Queensland's Moreton Bay Bug (*Thenus* spp.) and Balmain Bug (*Ibacus* spp.) stocks.

Moreton Bay Bugs (*Thenus* spp.) and Balmain Bugs (*Ibacus* spp.) are a valuable byproduct of Queensland's prawn and scallop trawl fisheries. The species caught in Queensland and their common names are provided in Table 1. The taxonomy of *Thenus* spp. has recently been reviewed by Burton and Davies (in press) and as a result their nomenclature may change in the near future.

Table 1. Bug species caught in Queensland's trawl fishery.

Common name	Species name
Moreton Bay Bug or Reef Bug	*Thenus orientalis*
Moreton Bay Bug or Mud Bug	*Thenus indicus*
Balmain Bug or Garlic Bug	*Ibacus chacei*
Balmain Bug or Honey Bug	*Ibacus brucei*
Balmain Bug	*Ibacus peronii*
Balmain Bug	*Ibacus alticrenatus*

Distribution

The spatial distribution of Bugs differs between genera and species. *Thenus* spp. is more tropical in distribution and dominates catches north of about 25°S compared with the more temperate *Ibacus* spp. which dominates south of 25°S.

Within the genus *Thenus*, *T. orientalis* is the larger of the two species and generally caught in greater depths, ranging from 30-60 m. The smaller species, *T. indicus* is generally taken in depths to about 30 m. Fishers do not record these two species separately in their logbooks, nor are they marketed separately. Thus, while the logbook provides a means of monitoring landings, the precise catch weight for each species is unknown. Field observations over several years indicate that Moreton Bay Bugs (*Thenus* spp.) dominate (by weight) landings in Queensland by a ratio of about 4:1 (*Thenus* spp. to *Ibacus* spp.). The price of Balmain Bugs ($/kg) is not as high as that for Moreton Bay Bugs, and therefore, the value of each species group is even more skewed towards *Thenus* spp.

Despite their name, landings of Moreton Bay Bugs from Moreton Bay are comparatively insignificant (< 15 tonnes). Moreton Bay receives a high level of trawl fishing effort (several thousand boat-days per year). There is anecdotal evidence to suggest that Bug catch rates in the Bay were once much higher than present, but this was prior to 1988 when the mandatory logbook database was introduced and as such, it is not possible to verify long-term trends for Moreton Bay. Logbook data show that the vast majority of Bug landings occur outside Moreton Bay.

The spatial distribution of *Ibacus* spp. is not as well understood as that for *Thenus* spp. because they have received very little research attention in Queensland. Fishers have only recently been permitted to retain Balmain Bugs in Queensland under the *Fisheries (East Coast Trawl) Management Plan* [Reprinted as in force 15th January, 2001], although they have been retained and marketed for many years. While *Thenus* spp. is managed as principal target species, *Ibacus* spp. is managed as "permitted species". Preliminary information on the spatial distribution of *Ibacus* spp. has been obtained from a current FRDC funded research project on trawl bycatch (FRDC#2000/170). The main Balmain Bug species in Queensland trawl catches appears to be the garlic bug *I. chacei* and is typically caught south of 25^{o}S in depths from about 40 m – 120 m. The honey bug *I. brucei* appears to be the second most common species and occurs in depths from 100 m – 200 m. *I. alticrenatus* is comparatively small and uncommon and generally caught in depths greater than 250 m. *I. peronii* has been reported from the Moreton Region (southeast Queensland) but has not been detected in trawl bycatch samples as yet.

Total annual reported Bug landings in Queensland have ranged from a maximum of 755 tonnes in 1997 to a minimum of 386 tonnes in 2001, declining markedly over the interim period (Figure 1). Assuming an average wholesale price of $12 per kilogram, the total annual landed value of the catch has fallen from $9.06 million (1997) to $4.6 million (2001) over the same period. The reasons for the decline over the past five years are unknown but possible explanations are discussed below.

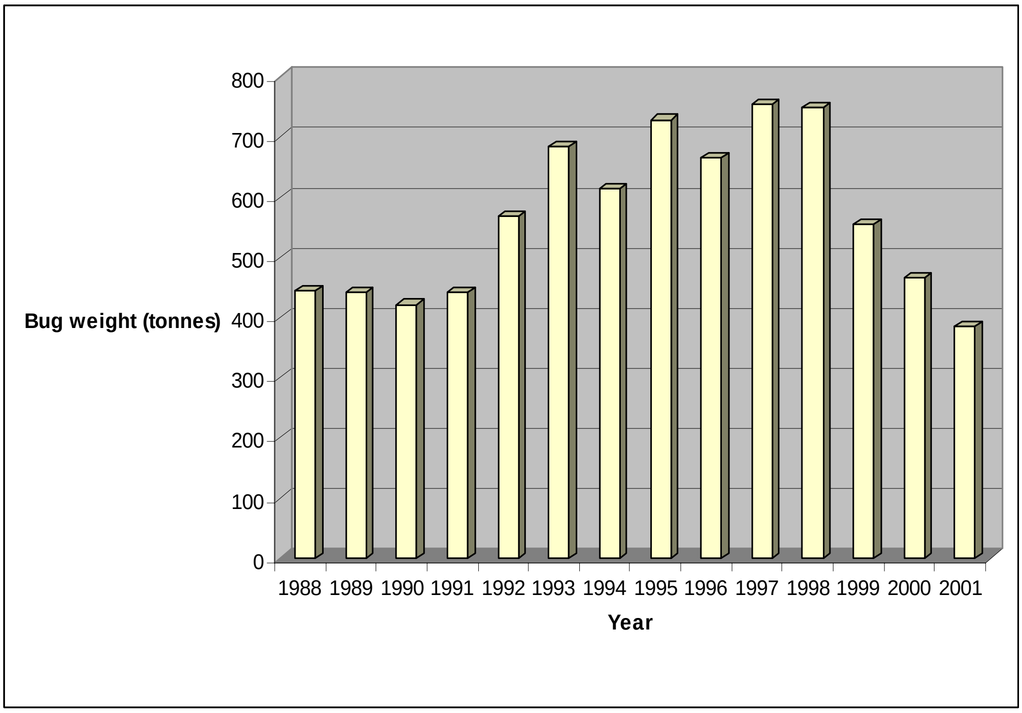

Figure 1. Total annual reported Bug landings, based on CFISH logbook data for the period 1988-2001. Species codes used for this data extraction include 700000-700800 inclusive (i.e., they include all possible bug codes) and as such such include both Moreton Bay Bugs and Balmain Bugs.

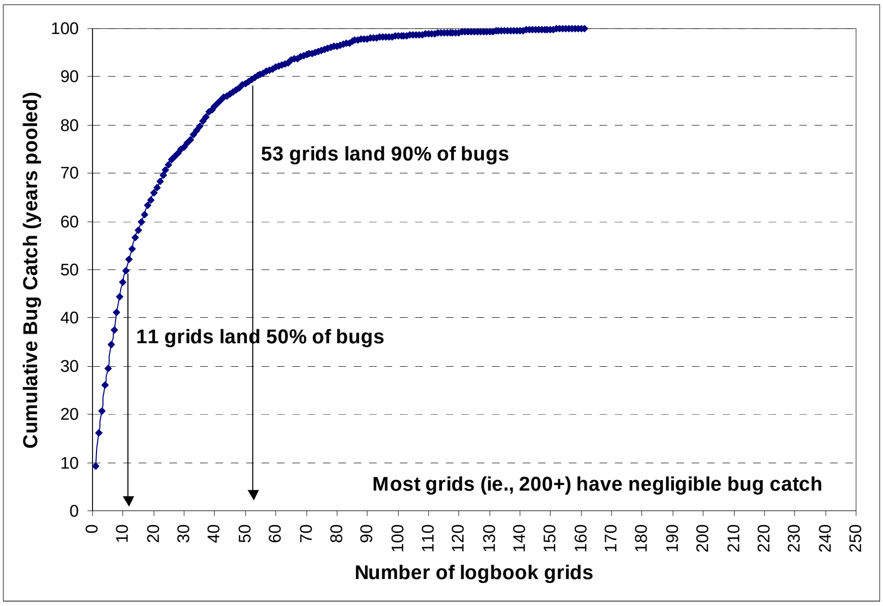

Figure 2. The relationship between cumulative Bug landings and the number of 30'x30' logbook grids. From the compulsory CFISH logbook database.

Highest landings, as reported from the logbook database for the period 1988-2001, occurred in relatively few 30’x30’ logbook grids (Figure 2). For example, about 50% of all landings occurred in 11 grids located near Townsville (logbook grids L21, K20, J20, M21, L22, M22, K21, J19) between 18^{o}30’S and 20^{o}S and Gladstone (logbook grids T30, S29 and T29) between 23^{o}S and 24^{o}S (Figure 3). Ninety percent of landings were reported from about 53 grids, with the remaining 200+ grids accounting for about 10% of the catch. The most highly productive grids, which were located near Townville, each produced 30-45 tonnes of Bugs annually (Figure 3).

Catch per unit effort

Because Bugs are a byproduct of trawling for prawns and scallops, the fishing effort expended during their capture is not targeted at them (although some low level targeting of Bugs is likely to occur). There is therefore, a need to clarify how fishing effort should be quantified in regard to Bug catch-per-unit-effort (CPUE). The CPUE data presented herein were based on all trawl fishing effort in selected grids over time – not just that effort associated with the Bug catch. It would be erroneous to use only that effort associated with Bug landings, as this would ignore the zero catches. For any given grid where Bugs occurred, the true level of effort applied to the stock was all trawl fishing effort, regardless of whether Bugs were caught.

The effort, landings and CPUE trends for the Townsville (logbook grids L21, K20, J20, M21, L22, M22, K21, J19) and Gladstone regions (T30, S29 and T29) are provided in Figures 4 and 5, respectively. The effort and CPUE time series were standardised to take account of annual fishing power increases since 1989. The coefficients for annual fishing power increase were obtained from O’Neill *et al.* (in press).

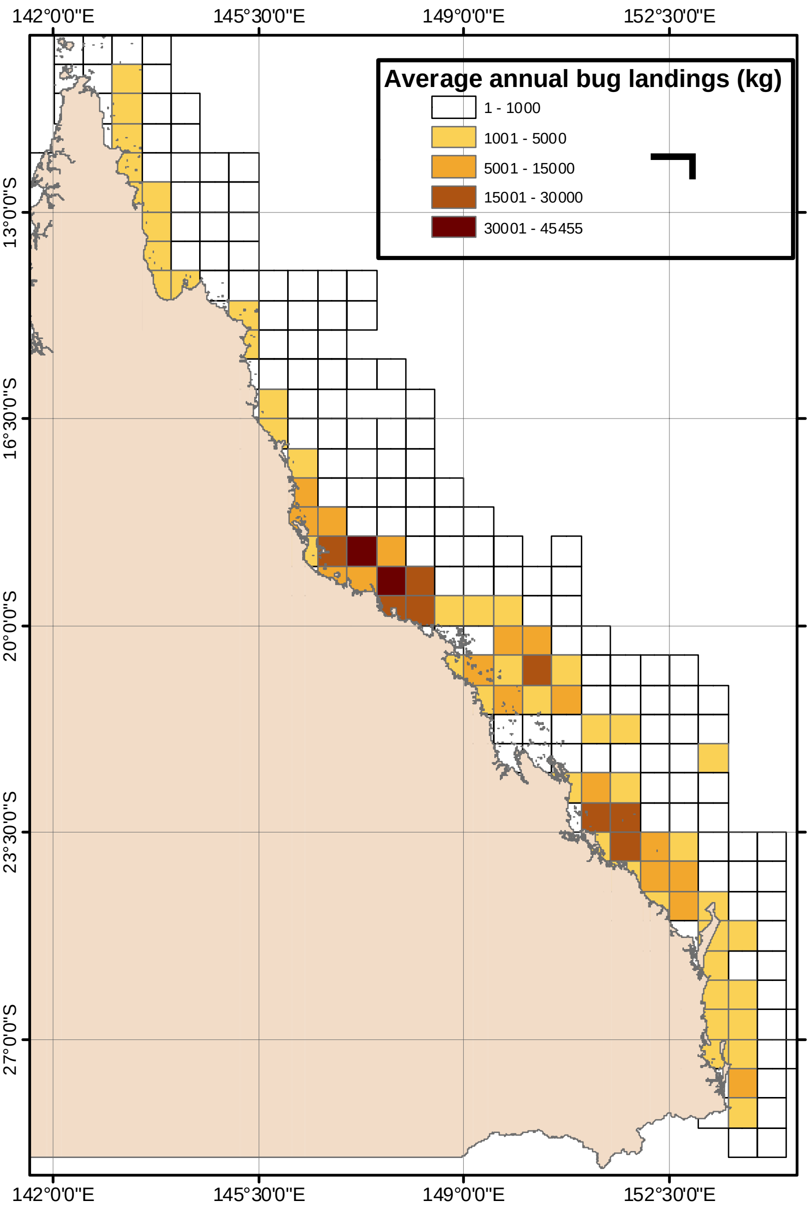

Figure 3. The spatial distribution of Bug landings in Queensland. The data are average annual landings (kilograms) for each 30'x30' CFISH logbook grid for the period 1988-2001, inclusive.

Monthly trawl fishing effort in the Townsville region displayed a marked seasonal trend that was characterised by the December-March closure each year (Figure 4). Effort tends to peak each year from May-July and since 1997 has been declining slightly. Monthly landings generally followed the effort pattern and showed a peak of about 35 tonnes in May 1997 followed thereafter by a decline. It is important to note that both effort and catch have been declining since 1997 (Figure 4).

The monthly CPUE also showed marked within-year variation, which maybe seasonal, however there appeared to be considerable variation in this pattern between years. There has been a slight decline in CPUE since 1997, however, catch rates in certain months in 2000 and 2001 were comparatively high. These data do not suggest a serious or significant decline in Bug CPUE in the Townville region, but rather, they indicate that catches have declined due to reductions in effort.

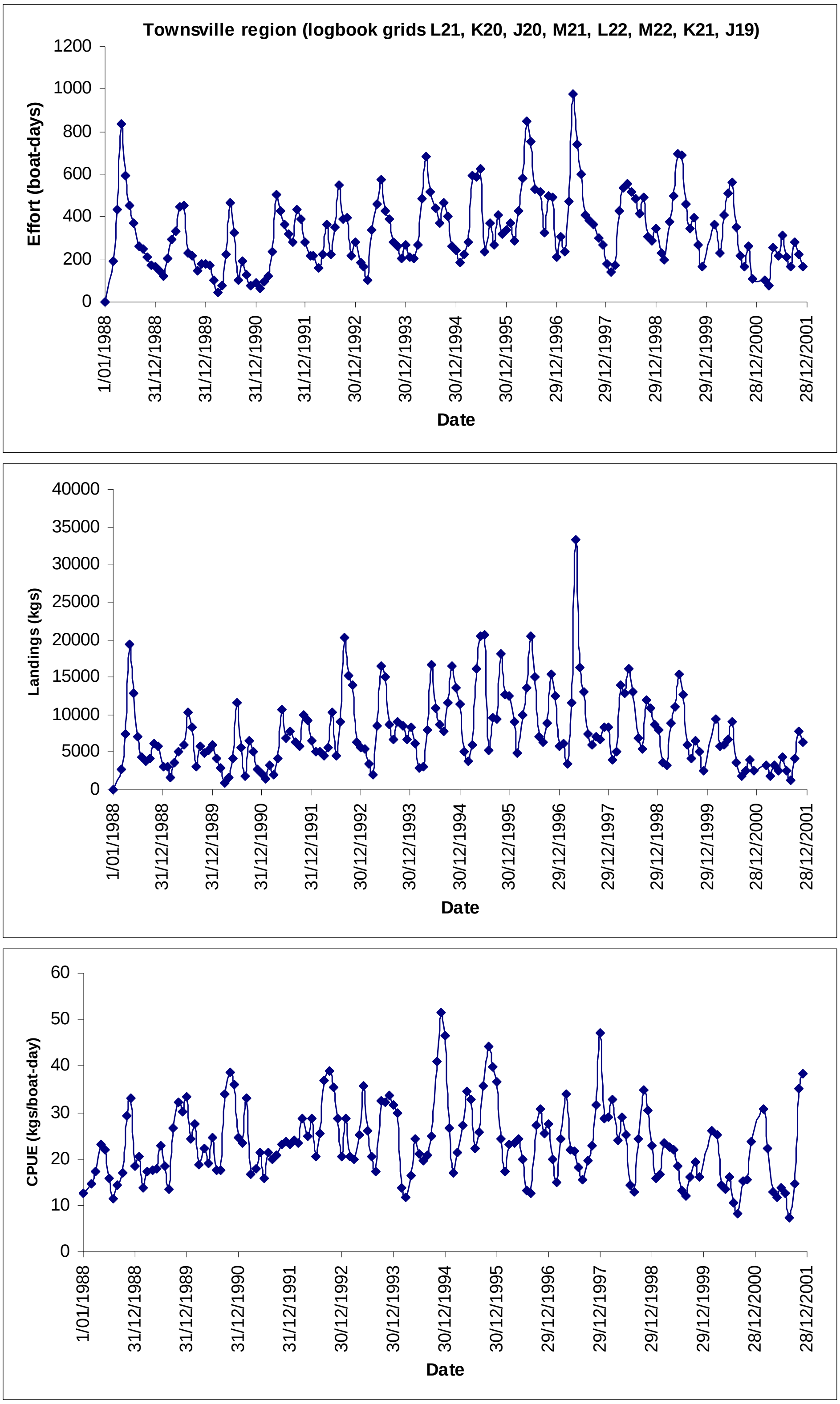

Figure 4. Long-term trends (1988-2001) in the monthly effort, catch and CPUE of Bugs in the Townsville region.

The seasonal patterns in landings, effort and CPUE were more clearly defined in the Gladstone region (Figure 5). Fishing effort displayed an annual peak in November.

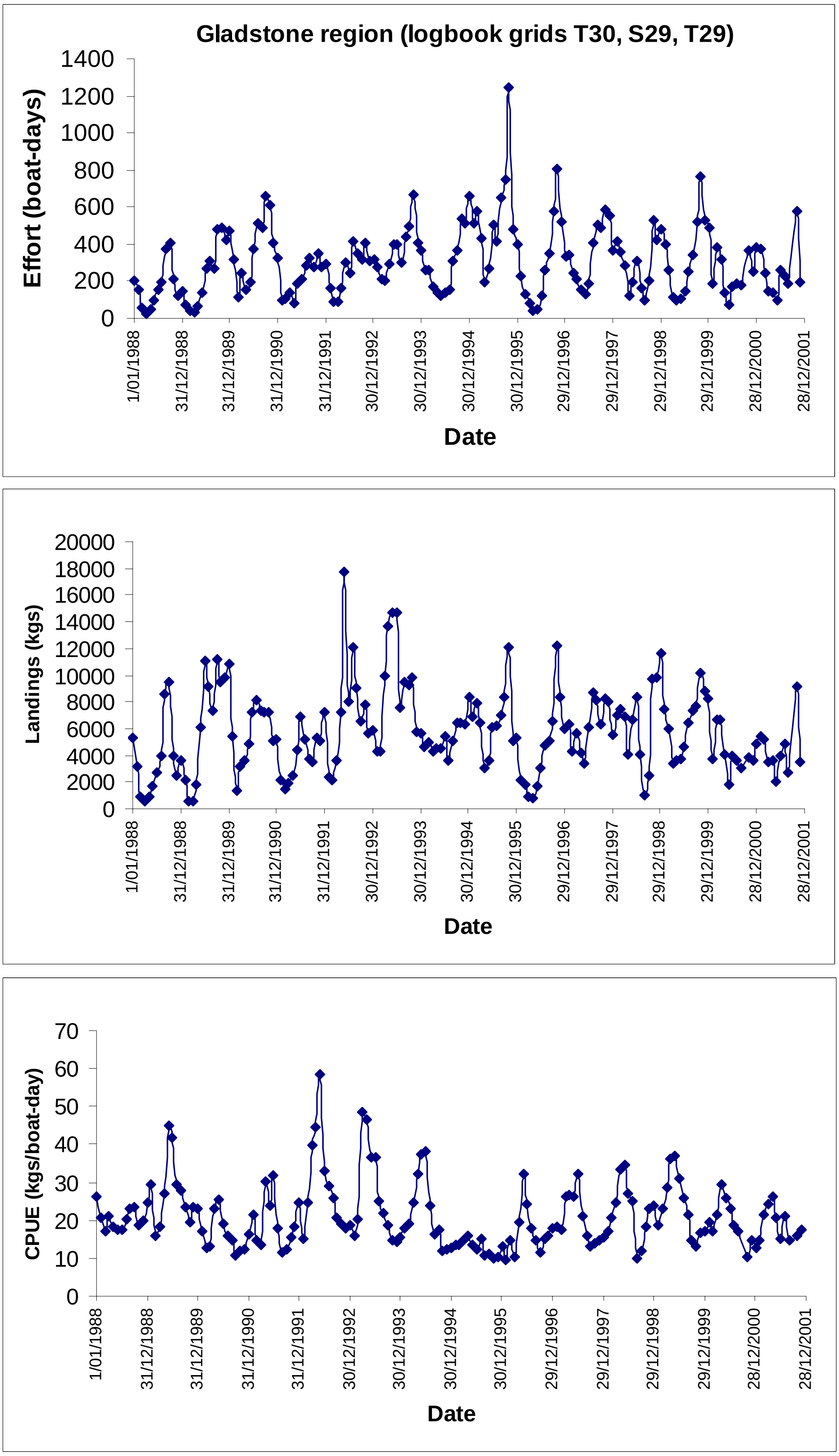

Figure 5. Long-term trends (1988-2001) in the monthly effort, catch and CPUE of Bugs in the Gladstone region.

This was the result of the pulse in fishing effort that occurred at that time each year and was associated with the annual reduction in the minimum legal size of scallops. Monthly fishing effort declined markedly to a minimum in May-June (Figure 5). Effort peaked at about 1,200 boat-days in November 1995 and has declined slightly since.

Landings appeared to be largely a function of effort and as such, tended to follow the effort pattern. In the more recent years, landings typically peaked in November and declined to annual minima in May-July. CPUE consistently peaked in May-July each year and fell to minima in October-November. There was no evidence to suggest a decline in CPUE for Bugs in this region.

Growth

Jones (1988) used a range of methods, including modal progression, functional analysis, intermoult/increment and progressive plotting to generate a composite description of growth rates for *T. orientalis* and *T. indicus* on the Queensland coast. (Note the species' nomenclature has changed since Jones' work). His definitive growth curves were:

T. indicus L_t (mm CL) = 91 x (1 – $e^{-0.002 \text{ per day } \times (t+79)}$)
T. orientalis L_t (mm CL) = 152 x (1 – $e^{-0.00075 \text{ per day } \times (t+160)}$)

More recently, Courtney (1997) used Fabens (1965) method of analysing tag-recapture data to describe growth rates for both species. These results are provided in Table 2 and presented graphically in Figure 6.

Table 2. Von Bertalanffy growth parameters for *Thenus* spp. obtained using Fabens' (1965) least-squares method for analysing tag-recapture data (from Courtney 1997).

Species and Sex	Minimum days at liberty	Number of recaptures analysed	K day^{-1} (95% C.I.)	L_∞ mm CL (95% C.I.)
Male *T. orientalis*	100	197	0.0014 (0.0013-0.0016)	77.45 (76.45-78.46)
Female *T. orientalis*	100	121	0.0016 (0.0014-0.0018)	89.04 (87.58-90.49)
Male *T. indicus*	30	73	0.0026 (0.0020-0.0031)	61.23 (58.46-64.00)
Female *T. indicus*	30	77	0.0023 (0.0019-0.0027)	72.44 (68.87-76.01)

Growth rates for the Balmain Bugs *I. peronii* and *I. chacei* have been described by Stewart and Kennelly (2000) using tag-recapture data and are provided in Table 3. At present *I. chacei* appears to dominate catches in Queensland and *I. peronii* has yet to be confirmed from commercial landings. Growth rates for *I. chacei* have not been quantified in Queensland and those presented in Table 3 from New South Wales should be considered with caution as they are based on relatively few individuals.

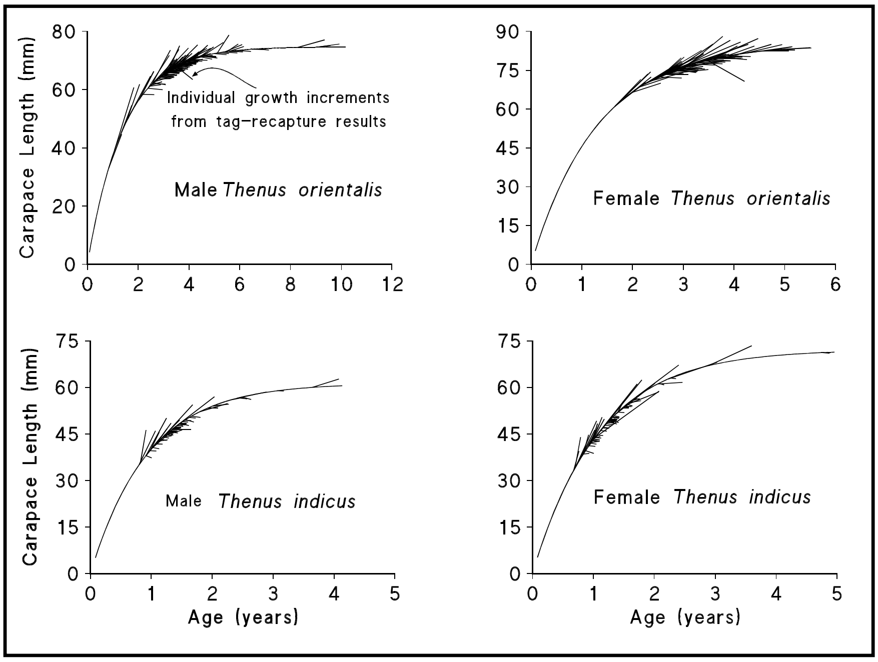

Figure 6. von Bertalanffy growth curves for Thenus spp., based on Fabens method of analysing tag-recapture data. (From Courtney 1997)

Table 3. Growth rates of Balmain Bugs from New South Wales (from Stewart and Kennelly 2000).

Species and Sex	Number of recaptures analysed	*K* year^{-1}	L_∞ mm CL
Male *I. peronii* (Coffs Harbour)	41	0.504	64.8
Female *I. Peronii* (Coffs Harbour)	36	0.431	81.1
Male *I. peronii* (Lakes Entrance)	30	0.346	69.3
Female *I. peronii* (Lakes Entrance)	21	0.323	78.2
Male *I. chacei*	9	0.440	72.8
Female *I. chacei*	26	0.730	71.9

Mortality rates and Exploitation

Instantaneous rates of natural mortality (*M*), total mortality (*Z*) and fishing mortality (*F*) were derived for *T. orientalis* in the Gladstone region in 1994 and 1995 using tag-recapture experiments at different times during the fishing season (see Courtney 1997 for details). These appear to be the only available mortality rate estimates for Bugs. Mortality rates for *T. indicus* and Balmain Bugs, *Ibacus* spp. have not been quantified.

The general approach was to firstly derive estimates of *M* and *Z*. Then, given that $Z=M+F$, *F* was estimated by deduction. Whenever tagging studies are used to measure mortality rates the rate of tag loss also needs to be considered. The instantaneous rate of tag shedding *T*, was therefore also measured from a four-month aquarium based laboratory experiment (see Courtney 1997, Courtney *et al.* 2001).

Natural mortality (*M*) was estimated for *T. orientalis* using a sequential tag-recapture experiment described by Ricker (1975) that relies on the difference in the recapture rate between two sequential tag-release experiments. One batch of tagged animals is released during a closed period and therefore only experience natural mortality over the period (i.e. no fishing mortality). The second batch is released when fishing is occurring and therefore experience both natural mortality and fishing mortality. The first batch of tagged lobsters were released in May 1994 when effort in the scallop fishery drops due to the seasonal increase in the minimum legal size of scallops. The second batch were tagged five months later in October 1994, just prior to the seasonal decrease in the minimum legal size. This is associated with a large annual pulse in fishing effort. Using this method, *M* can be estimated thus:

$$M_{T_2-T_1} = \ln\left({N_1^{'}} \big/ {N_1} \right)$$

where:

$N_1^{'} = N_2 Re_1 / Re_2$,

T_1 and T_2 are times at tag releases 1 and 2, respectively,

N_1 and N_2 are the numbers of lobsters tagged and released at times 1 and 2 respectively,

Re_1 *and* Re_2 are the numbers of lobsters recaptured from releases 1 and 2 respectively, and

$N_1^{'}$ is the number of survivors at time T_2.

A fundamental assumption underlying this method is that there is no fishing effort during the closed period (May-October), and therefore no fishing mortality. This assumption was violated during the study as there was some trawl fishing effort in the region. However, the level of effort was low and the impact on the derived estimate of *M* has been assumed to be small. The following estimate of *M* was obtained:

M_{T2-T1} = 0.406 per 23 weeks (duration of the quasi closed period) or 0.918 year^{-1}.

The instantaneous rate of tag shedding, *T* was from the laboratory-based aquarium experiment was estimated to be 0.141±0.09 per 119 days, or 0.432±0.276 year^{-1}.

Estimates of the instantaneous rates of fishing mortality *F* are provided in Figure 7. Throughout the study large batches of *T. orientalis* were tagged and released. Over 12,000 lobsters were tagged with approximately 10% recaptured (Courtney *et al.* 2001). Logbook data enabled the level of fishing effort in the area to be quantified as the lobsters were recaptured by fishers over the following months. Given that the natural mortality rate *M* and tag shedding rate *T* were quantified, estimates of the instantaneous rates total mortality (Z) and fishing mortality (*F*) were derived, using the exponential decay in the number of recaptures per unit of fishing effort.

The slopes of the graphs (Figure 7) represent the rate at which the tagged lobsters were removed from the population as a result of natural and fishing mortality and tag shedding/loss. Estimates of the instantaneous rate of fishing mortality (*F*) varied from 0.549 to 1.894 year^{-1} for female *T. orientalis* and 0.377 to 1.931 year^{-1} for males.

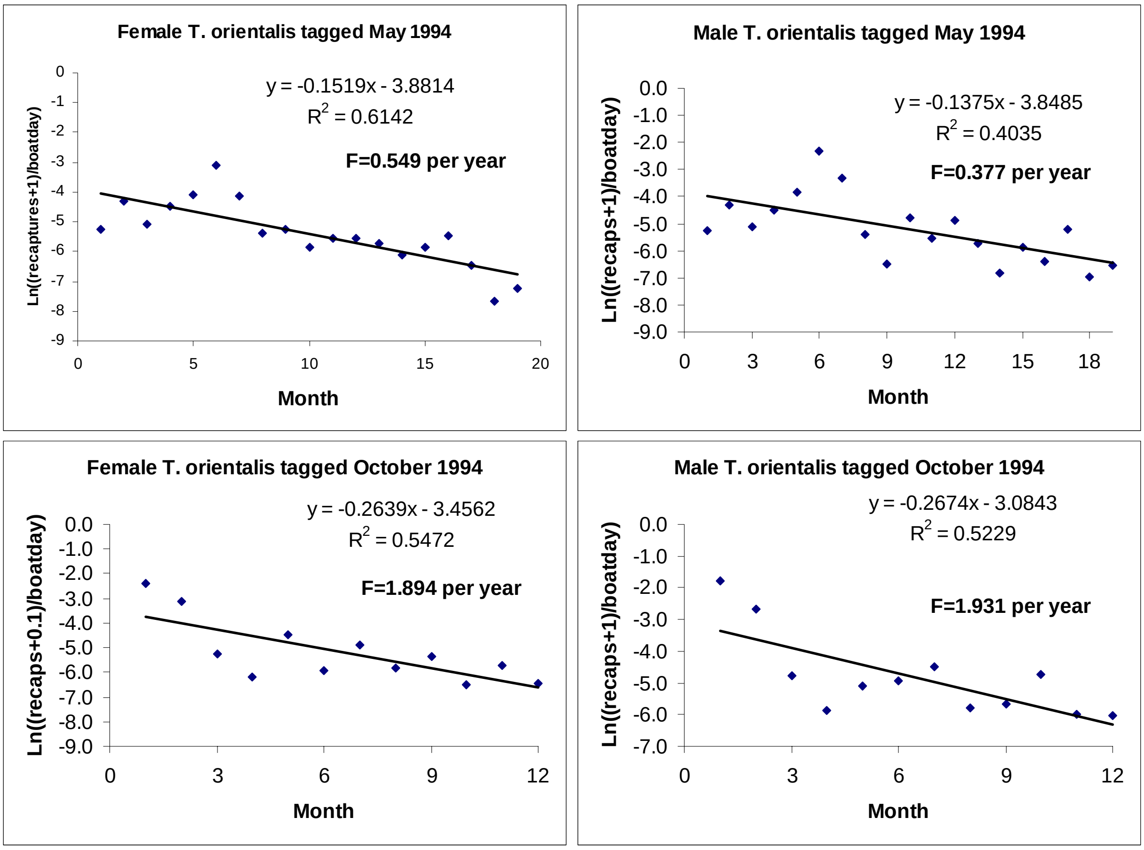

Figure 7. The relationship between recapture rate of tagged *T. orientalis* and the duration after tag-release. The slope of the graphs can be used to estimate fishing mortality rates.

Yield per recruit analysis and minimum legal sizes (MLS)

Yield per recruit is a standard steady-state model widely used for stock assessment and based on the early work of Beverton and Holt (1957). It is generally used to assess and determine the optimum levels of fishing mortality (F) and age or size at first capture. Yield per recruit is particularly suited for assessing Bugs stocks because they are a byproduct and therefore the range of management measures that are applicable to them is limited. For example, changes in mesh size, seasonal and spatial closures, and limitations on fishing effort are not applicable because they would affect landings of the target species. A minimum legal size (MLS) appears to be one of the few practical alternatives for managing Bug stocks.

The empirical methods for yield per recruit are well established. In a steady state fishery, yield per recruit can be estimated by:

$$Y/R = \exp(-M(t_c - t_r)) \sum_{i=t_c}^{i=t_l} \left\{ (F/(F+M)) \exp(-(F+M)(i-t_c)) \, (1-\exp(-(F+M)))W_i \right\}$$

where, Y = steady state yield of the fishery, R = number of recruits, M = instantaneous rate of natural mortality, F = instantaneous rate of fishing mortality, W_i = mean weight of fish aged i, t_r = age at recruitment to fishable stock, t_c = actual age of first capture, t_l = maximum age of fish in stock. Some rigorous assumptions underlie the equilibrium yield per recruit:

(i) recruitment is constant, yet not specified (hence the expression yield per recruit)
(ii) all fish (lobsters in the present study) of a cohort are hatched on the same date
(iii) fishing and natural mortalities are constant over the post-recruitment phase
(iv) fish older than t_l make no contribution to the stock.

The vulnerability to fishing mortality was assumed to be knife edged because Bugs are relatively large (compared with the trawl mesh size) and the period over their life span during which selectivity varies, is short. Lobsters younger than the age at first capture (t_c) were assumed to have zero vulnerability, while those equal to or older than t_c were assumed to be 100% vulnerable. Optimal ages at first capture were identified and converted to carapace width (mm CW) measures, which is likely to be the most practical body-length parameter used to implement a MLS. Only a single estimate of the instantaneous rate of natural mortality *M* was obtained from the tagging experiments on *T. orientalis* (0.918 year^{-1}). As no estimate of *M* was obtained for *T. indicus*, the same value (0.918 year^{-1}) was used for *T. indicus*. All yield per recruit simulations used this one estimate of *M*.

Emphasis was placed on *T. orientalis* as logbook catches indicate this species is the more valuable of the two *Thenus* spp. species in Queensland. At present we do not have all of the population parameter estimates required to undertake a similar assessment for Balmain Bugs, *Ibacus* spp. Simulations were also carried out for *T. indicus*. However, results for this species should be considered with caution because of greater uncertainty in its mortality rates.

For female *T. orientalis* maximum yield would be obtained by harvesting individuals at a relatively small size of about 47 mm CW and at a fishing mortality rate of about 0.8 year^{-1} (Figure 8).

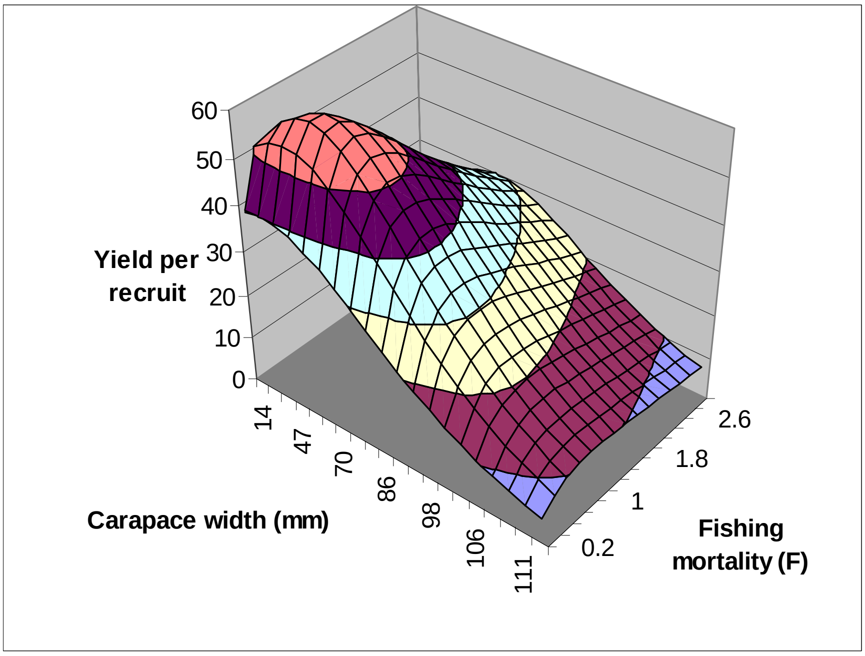

Figure 8. Yield per recruit for female reef Bugs, *Thenus orientalis*. Maximum yield would be obtained by harvesting at approximately 47 mm CW and at a fishing mortality rate of about 0.8 year-1. Tagging studies indicate that fishing mortality varies throughout the year from 0.549 to 1.894 year^{-1}.

For male *T. orientalis* maximum yield per recruit would be obtained by harvesting at 43 mm CW and a fishing mortality rate of 0.8 $year^{-1}$ (Figure 9).

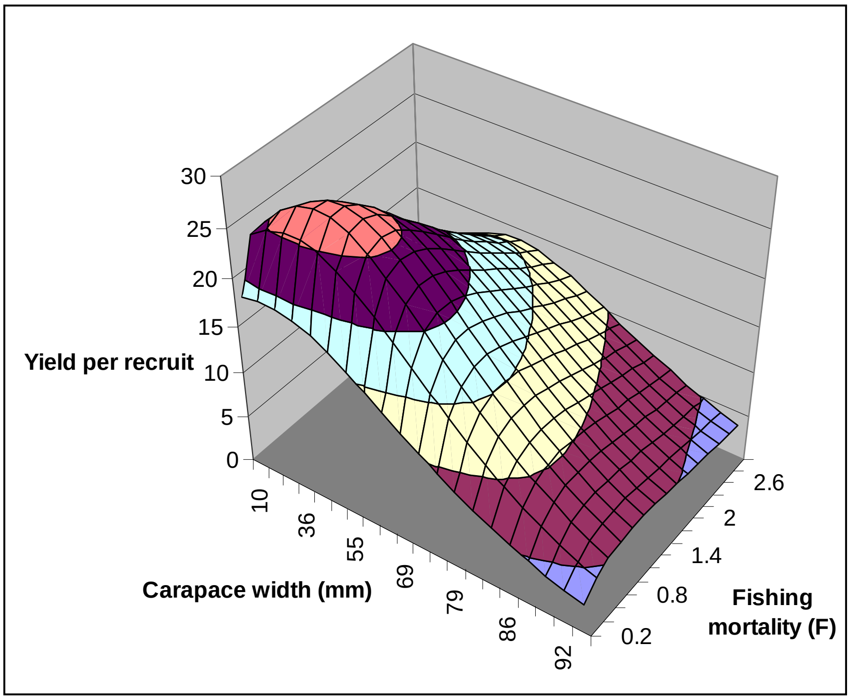

Figure 9. Yield per recruit for male reef Bugs, *Thenus orientalis*. Maximum yield would be obtained by harvesting at approximately 43 mm CW and at a fishing mortality rate of about 0.8 per year. Tagging studies indicate that fishing mortality varies throughout the year from 0.377 to 1.931 $year^{-1}$.

The yield per recruit for *T. indicus* is less reliable because no estimates of the instantaneous rates of natural mortality (*M*) or fishing mortality (*F*) have been derived. The estimate of *M* used for *T. orientalis* (0.918 $year^{-1}$) was therefore used in the analyses for male and female *T. indicus*. Maximum yield for female *T. indicus* would be achieved by harvesting at approximately 44 mm CW and at a fishing mortality rate of 0.8 $year^{-1}$ (Figure 10).

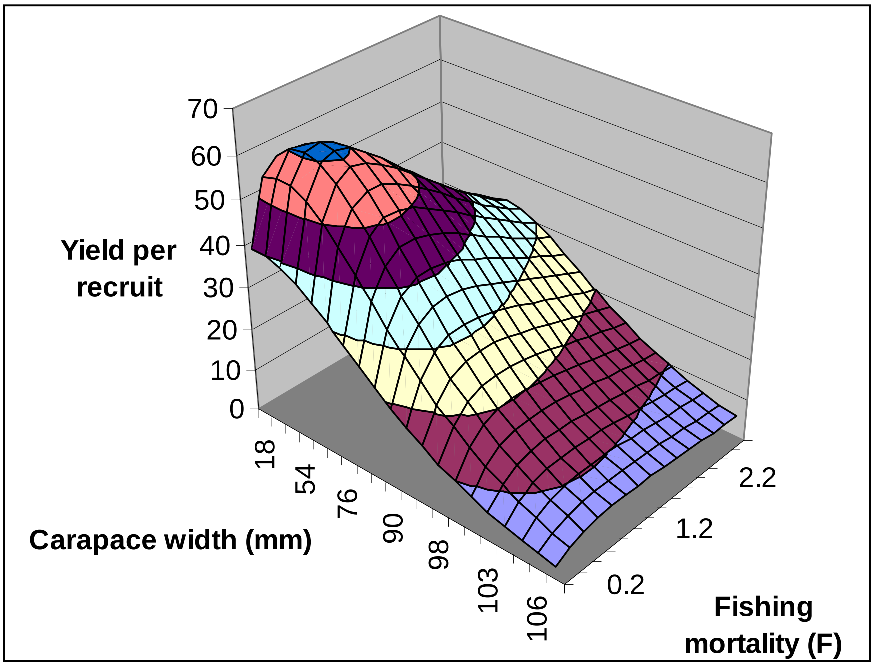

Figure 10. Yield per recruit for female mud Bugs, *Thenus indicus*. Maximum yield would be obtained by harvesting at approximately 44 mm CW and at a fishing mortality rate of about 0.8 per year. Mortality rates (*M* and *F*) for this species are largely unknown.

Maximum yield for male *T. indicus* would be achieved by harvesting at 46 mm CW and at a fishing mortality rate of 0.8 $year^{-1}$.

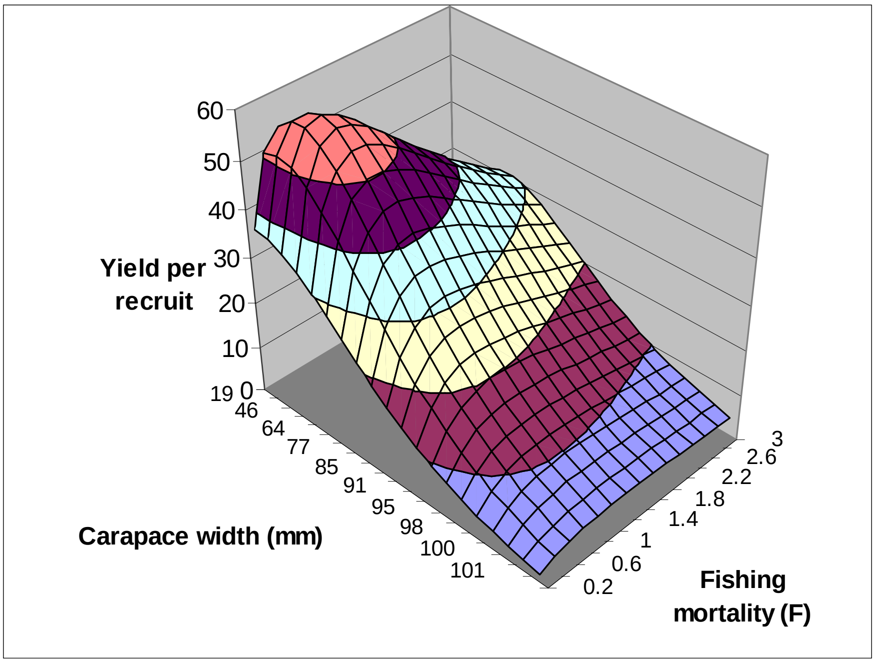

Figure 11. Yield per recruit for male mud Bugs, *Thenus indicus*. Maximum yield would be obtained by harvesting at approximately 46 mm CW and at a fishing mortality rate of about 0.8 per year. Mortality rates (*M* and *F*) for this species are largely unknown.

Collectively, these models suggest that maximum yield per recruit could be achieved by harvesting both species and sexes over a narrow size class range (from 43-47 mm CW). Interestingly, all four analyses indicated the same optimum fishing mortality level (0.8 $year^{-1}$). It is important to note however, that while yield could be maximised at these relatively small size classes, it would result in sub-optimal economic value of the catch because there is little, or no market for such small lobsters.

In order to examine the optimum age or size for maximising economic value, information on the price of different sizes of Bugs was obtained from processors and incorporated in the per recruit analyses (Figure 12). There are three general price categories; small lobsters 50-100g attract \$6-8 per kg, medium lobsters 100-220g attract \$10-12 per kg and large lobsters > 220g attract \$12-13 per kg.

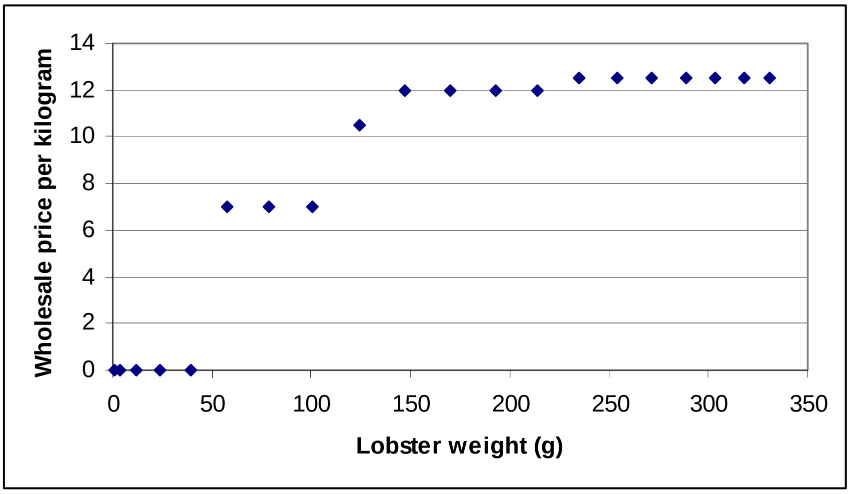

Figure 12. Approximate prices paid to fishers by seafood processors for different size classes of Thenus spp., based on phone interviews with processors.

When the yields were converted to their equivalent dollar-value the optimum size at which the lobsters should be harvested increased significantly. Figure 13 shows that the value per recruit for female *T. orientalis* would peak at about 85 mm CW for fishing mortality rates ranging from 0.6-1.2 year^{-1}. Female *T. orientalis* smaller than 57 mm CW have no marketable value and the value per recruit increases sharply from 57 mm CW (Figure 13). Above 85 mm CW the value per recruit declines as natural mortality reduces the population size and the number of lobsters available to fishing.

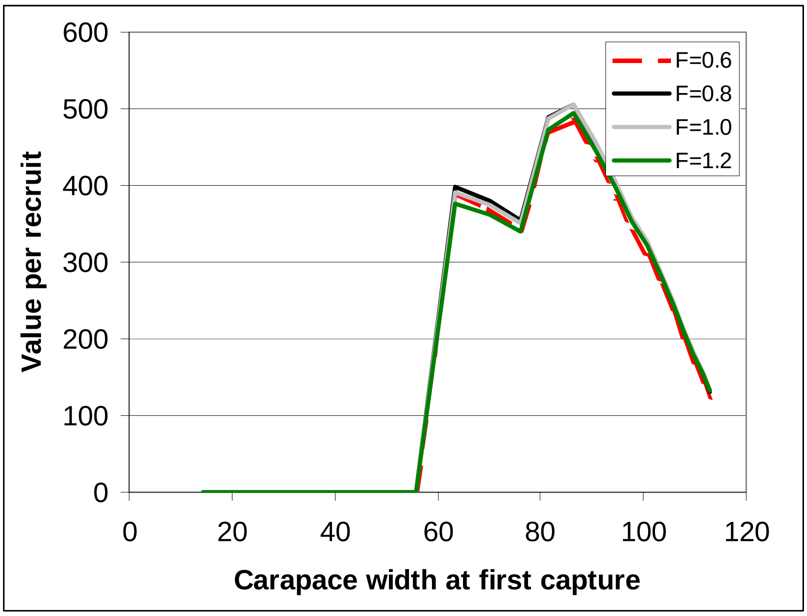

Figure 13. The value per recruit for female *T. orientalis* harvested at different minimum legal sizes and fishing mortalities from 0.6-1.2 year^{-1}.

Value per recruit for male *T. orientalis* is negligible up to about 60 mm CW as lobsters equal to, or smaller than this size have little or no market value. The value increases sharply from 60 mm CW, with two peaks of similar value at 65 mm CW and 79 mm CW (Figure 14), and declines thereafter due to natural mortality effects.

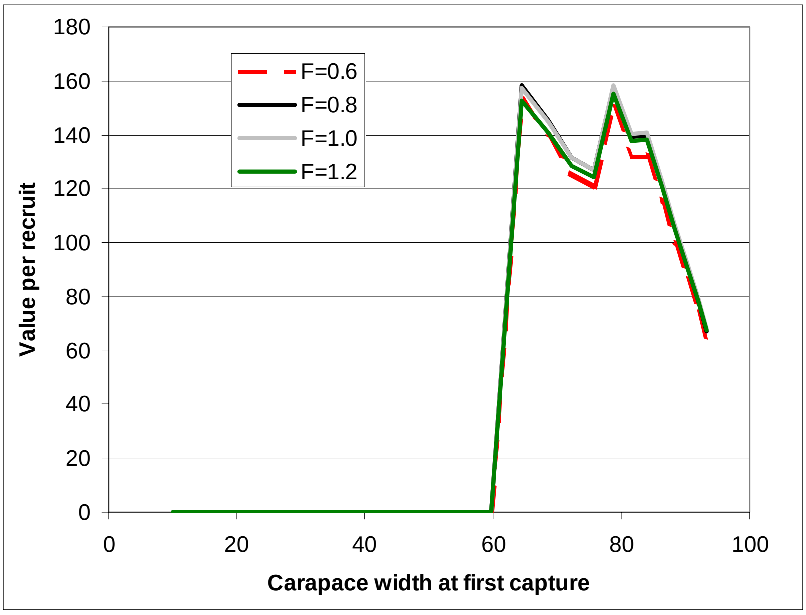

Figure 14. The value per recruit for male *T. orientalis* harvested at different minimum legal sizes and fishing mortalities from 0.6-1.2 year^{-1}.

Maximum value per recruit for female *T. indicus* would be obtained by harvesting at 82-86 mm CW for fishing mortalities ranging from 0.6-1.2 $year^{-1}$ (Figure 15). Female *T. indicus* that are smaller than about 63 mm CW weigh less than 50 g and since there is no market for such small size classes, the value per recruit for sizes less than or equal to this would be negligible.

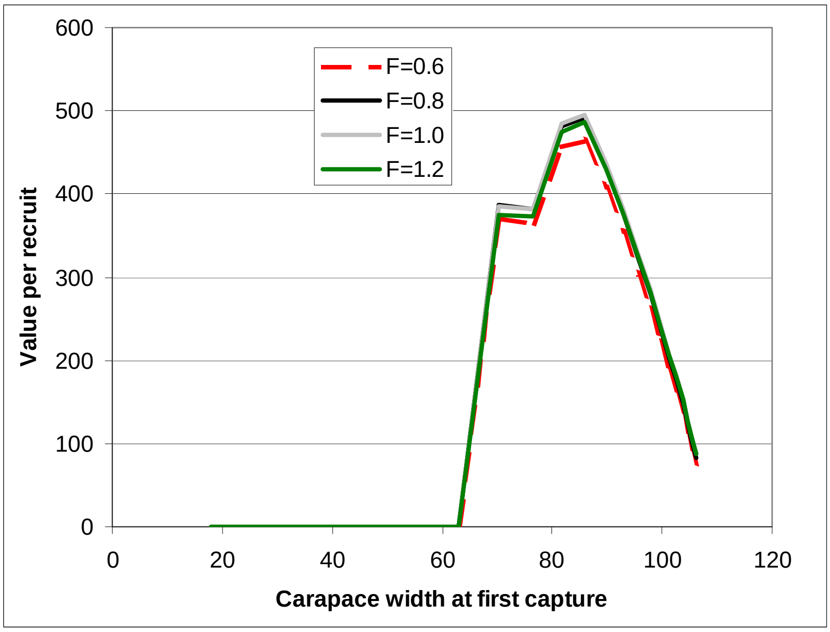

Figure 15. The value per recruit for female *T. indicus* harvested at different minimum legal sizes and fishing mortalities from 0.6-1.2 $year^{-1}$.

Male *T. indicus* are the smallest of the 4 groups considered. Their value per recruit would be maximised by harvesting at about 81 mm CW and declines sharply thereafter.

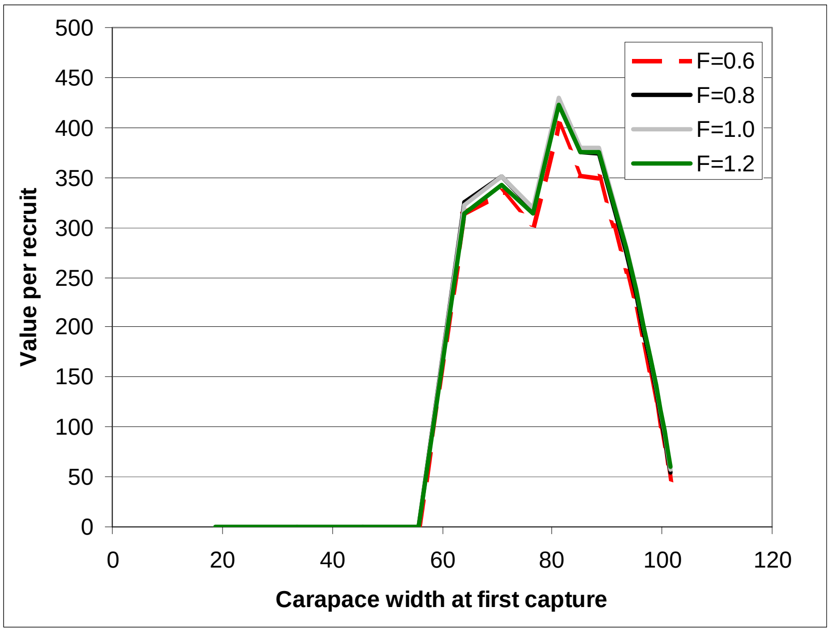

Figure 16. The value per recruit for male *T. indicus* harvested at different minimum legal sizes and fishing mortalities from 0.6-1.2 $year^{-1}$.

The current minimum legal size for Moreton Bay Bugs in Queensland is 75 mm CW and below the maximum value per recruit for female *T. orientalis* (maximum value achieved at 85 mm CW). 75 mm CW is reasonable for male *T. orientalis* as the simulations indicate the value for this species would be maximised at either 65 mm CW or 79 mm CW. The current minimum legal size of 75 mm CW is below the maximum for both female and male *T. indicus*, whose values would be maximised at 82-86 and 81 mm CW, respectively.

The current MLS for Balmain Bugs is 100 mm CW and has not been evaluated.

Conclusions

Logbook records indicate that total landings of Bugs in Queensland have declined significantly over the past 5 years. However, there is no evidence of a significant decline in CPUE in the major areas near Townsville and Gladstone and the decline in landings appears largely due to reductions in fishing effort.

The current FRDC funded bycatch project (FRDC#2000/170) has obtained some data from opportunistically sampling on board commercial vessels which indicates that TEDs (Turtle Excluder Devices) are significantly lowering the retention of Bugs, particularly in the scallop sector off Gladstone, but further observations are needed to verify this.

The current 75 mm CW minimum legal size that is applied to Moreton Bay Bugs is likely to be below that associated with the maximum value per recruit that is achievable for *T. orientalis* and *T. indicus*. The value of the Bug catch could be increased by increasing the minimum legal size to 80 mm CW, but the precise optimum for all four species/sexes is unknown. This would also increase egg production and may also lower the likelihood of recruitment overfishing.

Further per recruit analyses are required for Bugs, in particular a multi-species, multi-sex model aimed at maximising the value for both species. Mortality rates (*F* and *M*) for *T. indicus* are still largely unknown and need to be quantified. Extremely little is known about the key population parameters for Balmain Bug species, *Ibacus* spp. in Queensland, particularly growth and mortality rates which need to be addressed before any simulations or reliable recommendations can be put forward. The value per recruit results for *Thenus* spp. are sensitive to price variation and should be updated periodically, or whenever market prices vary.

References

Beverton, R. J. H. and Holt, S. J. (1957). On the dynamics of exploited fish populations. Fish. Invest. Minist. Agric. Fish. Food. G. B. (2 Sea Fish.), 19: 533 p.

Courtney, A. J. (1997) A study of the biological parameters associated with yield optimisation of Moreton Bay bugs, *Thenus* spp. **Fisheries Research and Development Corporation (FRDC) Final Report Project #92/102.** 45p.

Courtney, A. J., Cosgrove, M.G. and Die, D. J. (2001) Population dynamics of Scyllarid lobsters of the genus *Thenus* spp. on the Queensland (Australia) east coast. I. Assessing the effects of tagging. *Fisheries Research* 53(3): 251-261.

Fabens A. J. (1965). Properties and fitting of the von Bertalanffy growth curve. *Growth*, 29(3): 265-289

Jones C. M. (1988). The biology and behaviour of bay lobsters, Thenus spp. (Decapoda: Scyllaridae), in Northern Queensland, Australia. PH.D. Thesis, University of Queensland, Brisbane, Australia

O'Neill, M. F., Courtney, A. J. Turnbull, C. T., Good, N. M., Yeomans, K. M., Staunton Smith, J., and Shootingstar, C. (in press) Comparison of Relative Fishing Power between Different Sectors of the Queensland Trawl Fishery, Australia. *Fisheries Research*

Ricker, W. E (1975). Computation and interpretation of biological statistics of fish populations Bulletin of the Fisheries Research Board of Canada 191

Stewart, J. and Kennelly, S. J. (2000). Growth of the scyllarid lobsters *Ibacus peronii* and *I. chacei. Marine Biology* 136: 921-930.