September 2001

Research for Management of the Ornate Tropical Rock Lobster, *Panulirus ornatus*, Fishery in Torres Strait

Annual Report to TSFSAC#36; September 2001

C.R. Pitcher

D.M. Dennis

T.D. Skewes

T. Wassenberg

M.D.E. Haywood

D. Brewer

D. R. Jacobs (AFMA)

R. Ware (AFMA)

CSIRO Division of Marine Research

Marine Laboratories

PO Box 120

Cleveland, Queensland 4163

CSIRO
MARINE RESEARCH

Summary

The aims of the project are to provide managers with information and advice to facilitate sound management of the Torres Strait tropical lobster fishery, by undertaking stock assessment and biological research. The research objectives include: annual population surveys; annual Islander catch monitoring, parameter estimation (growth, mortality and recruitment); and fisheries dynamics modelling.

In 1989, absolute lobster abundance in Torres Strait was estimated by visual census of 572 sites distributed over the ~25,000 km^2 area of the fishery (Pitcher *et al.*, 1992). In that year there were between 11-17 million lobsters in Torres Strait, of which about 8 million were legal-size. The estimated stock size was 2200 to 3350 t tail weight, which was about ten-fold greater than the annual catch of ~250 t.

Since 1989, monitoring of the lobster population has continued at a sub-set of 100 (1990-1995) or 82 (1996-2000) of the 572 sites used in 1989, to determine the relative abundance of the recruiting and fished year-classes (1+ and 2+ years old respectively). These fishery independent surveys were conducted during May/June each year — the eleventh annual survey of the Torres Strait lobster population was completed in June 2000.

The 2000 2+ year-class was the second smallest of those previously recorded, and was only 25% greater than the record low in 1999. The low stock abundance was not anticipated at TSFSAC#34 because the 1999 1+ year-class was among the largest recorded. The low abundance of 2+ lobsters was evident in all quadrants, although 2 + abundance in the SW was similar to the long-term average. The unexpected low 2000 stock, given the above average 1999 recruiting

year-class suggests that natural mortality during 1999/00 was very high. The updated fishery model developed by CSIRO estimated natural mortality at about 60% (M=1.478). The cause of this high natural mortality may have been related to habitat changes in NW Torres Strait reported by fishers.

The 2000 recruiting year-class was similar to the lowest previously recorded in 1993 and 1998, and was only 63% of the previous year's level. The 2000 abundance of 1+ lobsters was low in all quadrants of the fishery, although the abundance in the NW quadrant was similar to the long-term average. This low recruit abundance across all quadrants was not anticipated given the above average 1998 stock (and presumably breeding population also). Recruiting 1+ lobsters in the NW quadrant were also significantly smaller than in previous years, perhaps also as a result of the habitat changes during 99/00 reported by fishers. As a result the catch per unit effort of 1+ year old lobsters in the NW quadrant was the lowest of those previously recorded.

As a consequence of the low stock and recruit abundance, the combined Aust/PNG catch for 2000 (205 t) was similar to the low 1999 catch (214t).

The twelfth annual survey was recently completed in May/June 2001 and confirmed expectations and re-enforced concerns. The 2001 2+ year-class was the lowest recorded to date, only 70% of the previous record low in 1999. This low abundance was foreshadowed, given that the 2000 1+ recruiting year-class was very low. Fishers and processors have corroborated the very low abundance of 2+ lobsters in 2001. The 2001 1+ recruiting year-class was also the lowest recorded to date; only 65% of the previous record low in 1998. This low recruitment was foreshadowed at TSFSAC #32 as a result of the low stock abundance in 1999 (and presumably breeding population). Consequently, the 2002 fishable

stock and total catch are likely to be smaller than any previous years.

The overall catch per unit effort (CPUE) of the island-based fishery in mid-2000 (1.62 kg/diver/hr) was similar to the average since 1990 (1.71 kg/diver/hr). The island-based CPUE has been extremely consistent since 1990, ranging by only 30% (1.48-1.95 kg/diver/hr), even though stock levels have varied widely (>400%) in the same years. However, as reported previously the consistent catch-rate is probably due to changes in fishing behaviour, such as restricting diving to peak times. Contrasting with the previous year (1999), the proportion of 1+ lobsters, relative to 2+ lobsters in the catch was a record low (4%). This contrasts with previous years of low stock abundance (1993,94, 99) as fishers generally take greater proportions of 1+ lobsters when 2+ lobsters are less abundant, to sustain catch rates. It is likely that the low percentage of 1+ lobsters taken in 2000 was due to the relatively small size of recruiting lobsters (almost all less than legal size).

As in all previous years, the CPUE of hookah divers (1.94 kg/diver/hr) was higher than for free divers (1.41 kg/diver/hr), but the difference in catch-rates between these methods is not widening.

Continuing the overall trend observed since the annual surveys began there was a general agreement for 2+ lobster abundance between the CPUE of the 2+ lobsters in the catch and the number of 2+ lobsters seen during the annual surveys.

Data collected in the field research sub-projects continues to be synthesised to provide stock status assessments for management. Following the recommendations of the Tropical Rock LobsterFishery AssessmentGroup Workshop held in March 2000 the stock assessment model has been refined to become a dynamic

model and allow status of the fishery to be assessed relative to Biological Reference Points, taking into account known uncertainties by incorporating confidence limits around parameters from the annual surveys.

Updated dynamic stock assessment modelling of the fishery confirmed that the lobster stock is over-exploited. The stock has fished down by relatively excessive catches through the mid-late 1990's and the recent average Fishing Mortality (F) was F~0.282, whereas a more sustainable level is estimate at F<0.21. The model showed that the fishery is at significant risk relative to the key 'not-to-be-exceeded' Biological Reference Points based on the Stock-Recruitment Relationship. The current status of the fishery was assessed relative to the stock **B**iomass ($B_{50\%}$) that produces half (50%) of the maximum Recruitment ($R_{50\%}$) and the fishing mortality associated with this point ($F@R_{50\%}$). Currently the probability that future recruitment is less than $R_{50\%}$ is ~40-70% and the probability that future stock is less than $B_{50\%}$ is ~40-70%. Assuming no increase in effort the probability that future fishing mortality will exceed $F@R_{50\%}$ is ~25-40%. However, if effort increases, these risks and that of failed recruitments & stocks increase dramatically.

Given the high probability that future fishing mortality would exceed $F@R_{50\%}$, several management measures that could be implemented quickly were evaluated for their effectiveness, using the updated fishery model. Increasing the current minimum size (Ls) was seen as one of the most effective measures. By increasing Ls from 100 to 115 mm Tail Length (TL), the probability that future recruitment is less than $R_{50\%}$ is lowered to ~15-40%; the probability that future stock is less than $B_{50\%}$ is lowered to ~15-35%; and the probability that future fishing mortality is greater than $F@R_{50\%}$ is lowered to ~0-3%. Provided there is no increase in effort, future recruitments and stocks would likely be higher and fishing mortality may be F ~ 1.1 to 1.6 with the increased minimum size. Further, by

increasing the minimum size and with current effort, future catches may be slightly greater than if no action is taken — this is because future stocks should recover to higher levels and any lobster caught will be heavier.

Increasing the closed season on hookah from 2 months (Oct-Nov) to 4 months (Oct-Jan) has little apparent benefit unless Ls is also increased. However, the Oct-Jan closed season has a slight benefit when combined with Ls = 115 mm TL and is a popular option among many Islander fishers.

Implementing Ls = 115 mm TL and an Oct-Jan closed season has the immediate benefit of bringing fishing mortality down to sustainable levels with the current level of participation in the fishery. However, the fishery is very unlikely to bounce back quickly in the short term, and may take at least 3–9 years to recover to the projected levels of stock and recruitment — this is the case even if the fishery was completely closed for several years.

There is very substantial latent potential effort that may enter the fishery as it recovers, thus negating a full recovery. Thus, the issue of controlling total effort in the fishery must also be addressed as soon as possible.

Consideration should be given to encouraging the live fishery because it adds value to what is currently discarded and prices paid for live lobsters per kg are similar to those for tails per kg, suggesting that the value of the fishery could be maintained while catching 60% fewer lobsters, which in turn would lead to even higher future stock levels.

Introduction

The aims of the project are to provide managers with information and advice to facilitate sound management of the Torres Strait tropical lobster fishery, by undertaking stock assessment and the essential research to support it. The research objectives include: annual population surveys; annual Islander catch monitoring, parameter estimation (growth, mortality and recruitment); and fisheries dynamics modelling. This annual report summarises activities undertaken since July 2000, including analyses of the June 2000 annual survey and catch monitoring data, a major revision of the assessment model, and completion of the twelfth annual lobster survey in June 2001. Preliminary analysis of data from the most recent survey has been completed (as part of the 2001-2002 Project) and initial results are reported here. This document has been prepared to meet the internal requirements of the TSFSAC and should not be cited without reference to the authors.

Progress 2001

Annual Population Survey

Summary of past surveys to date

The absolute abundance of lobsters in Torres Strait was estimated by visual census of 572 sites distributed over the ~25,000 km^2 area of the fishery (Pitcher *et al.*, 1992) in May/June 1989. In that year there were between 11-17 million lobsters in Torres Strait, of which about 8 million were legal size. The estimated stock size was 2200 to 3350 t tail weight, which was about ten-fold greater than the annual catch of ~250 t.

Since 1989, monitoring of the lobster population has continued at a sub-set of 100 (1990-1995) or 82 (1996-2001) (Fig. 1) of the 572 sites used in 1989, to determine the relative abundance of the recruiting and fished year-classes (1+ and 2+ years old respectively). These fishery independent surveys were conducted during May/June each year — the eleventh annual survey of the Torres Strait lobster population was completed in June 2000.

Lobsters were counted and collected by 2 divers during timed swims at each site located throughout central and western Torres Strait (Fig. 1). The abundance and size distribution data were used to calculate fishery independent indices of the relative abundance of the recruiting (1+) and fished (2+) year-classes. The abundance indices were compared with indices from previous years and provided information on the relative strength of both year-classes and forewarning of trends in future stock size. Abundance data recorded in 1989 were adjusted to account for different survey methods (measured versus timed transects). The abundance indices are compared with CPUE information recorded during the catch monitoring sub-project (see next section).

Mid-year abundance of 2+ lobsters has been about one half (1990,1992) to one quarter (1991,1993-98) of that recorded in 1989 (Figs. 2,3). However, recent stocks (1999-2001) fell to an all time low of about 15% of the 1989 level. Prior to 2000, there was no concurrent year-to-year downward trend in the abundance of recruiting lobsters, although abundances were very low in 1993 and 1998. Presumably, the recruitment that preceded the large 1989 stock (ie. the 1988 1+ year-class) was much more abundant than any observed during subsequent surveys. However, since 1999 there has been a significant decline in the abundance of recruiting lobsters to an all time low in 2001. These trends are corroborated by CPUE's of 1+ and 2+ lobsters in the commercial catches for the same years (see Fig. 9, next section).

Overall, the 2+ lobster abundances recorded during the surveys were highly variable among years (1990-2001) in all quadrants of the fishery (Fig. 4). In contrast, CPUE data recorded in the same years showed that the variation in catch-rate of 2+ lobsters was relatively small, except for an unusually high catch-rate in 1997 (see Fig. 9). Prior to 2000, the 1+ lobster abundances recorded during the surveys, although variable, showed no clear year-to-year downward trend, suggesting recruitment was generally stable (but see Stock Assessment Section). However, recent low abundances now suggest that recruitment levels would not sustain recent catch levels. The CPUE data indicates that 1+ lobsters comprise only a small fraction of the mid-year island-based catch, although more are taken when 2+ lobster abundance is low, as in 1993/94 and in 1999 (Fig. 9). However, the catch-rate of 1+ lobsters in the 1988 catch was more than two-fold greater than in any subsequent year and the resulting 2+ year-class in 1989 was unusually large (Fig. 2). The catch-rate of 1+ lobsters fell to a record low in 2000 due to low abundance combined with very slow growth, possibly as a result of habitat change in NW Torres Strait.

The record low stock abundance in 1999 prompted a workshop on Torres Strait lobster fishery assessment, which was convened in March 2000 and attended by CSIRO researchers, AFMA managers and stock assessment experts. The workshop concluded that the record low 1999 stock raised serious concerns about the long-term sustainability, particularly given the likelihood of a record low recruitment in 2001. The workshop also concluded that the fishery is likely exceeding B_{50} (a biological reference point at which the spawner biomass will produce half the recruitment strength of that in an unfished state) and that the fishery model should be revised to assess the long-term risks. The fishery model has since been updated to allow assessment of the status of the stock against these biological reference points.

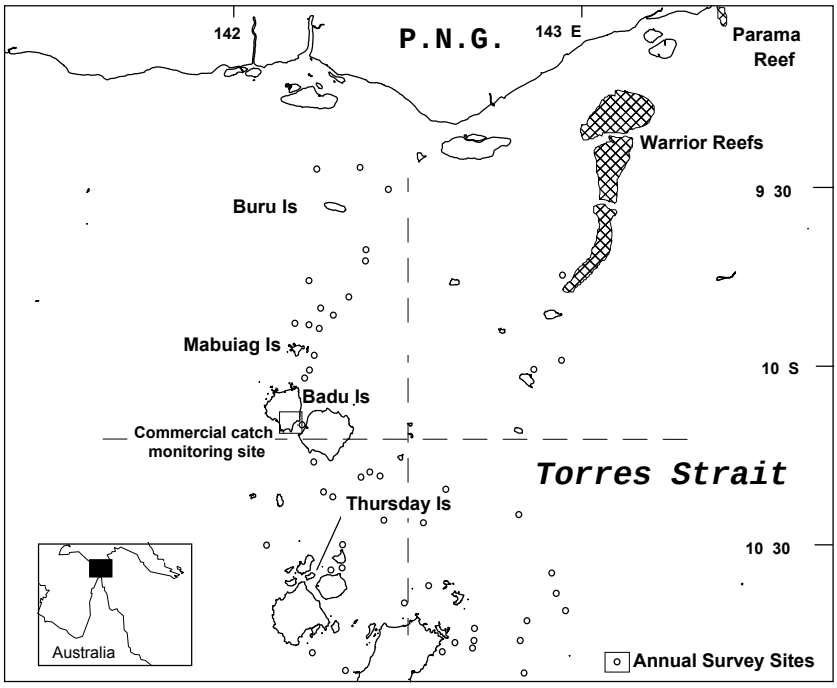

Fig. 1. Map of Torres Strait showing sites (2 dives are done at each site) surveyed between 1989-2001 and the division of the study area into 4 quadrants to allow assessment of spatial differences in abundance of lobsters. The location of the land-based processor where commercial catch and effort is monitored is also shown.

2000 Annual Survey

The eleventh annual survey of the Torres Strait lobster population was completed in June 2000

The eleventh annual survey of the Torres Strait lobster population was conducted during June 2000 by 5 CSIRO staff, using the vessel *R. V. James Kirby*.

Since 1996, a sub-set of 82 sites from the original 100 sites have been surveyed (Fig. 1) to determine the relative abundance of recruiting (1+) and fished (2+) lobsters in western Torres Strait. The distances surveyed during each timed dive at a site have been recorded using GPS between 1993-2001. The average distances surveyed fell within a small range, indicating that the sampling method was consistent between years. Since 1998 lobsters have been counted in 500 m transects, measured using a Chainman ® device, and abundances were re-scaled to 20 minute swims using the time swum.

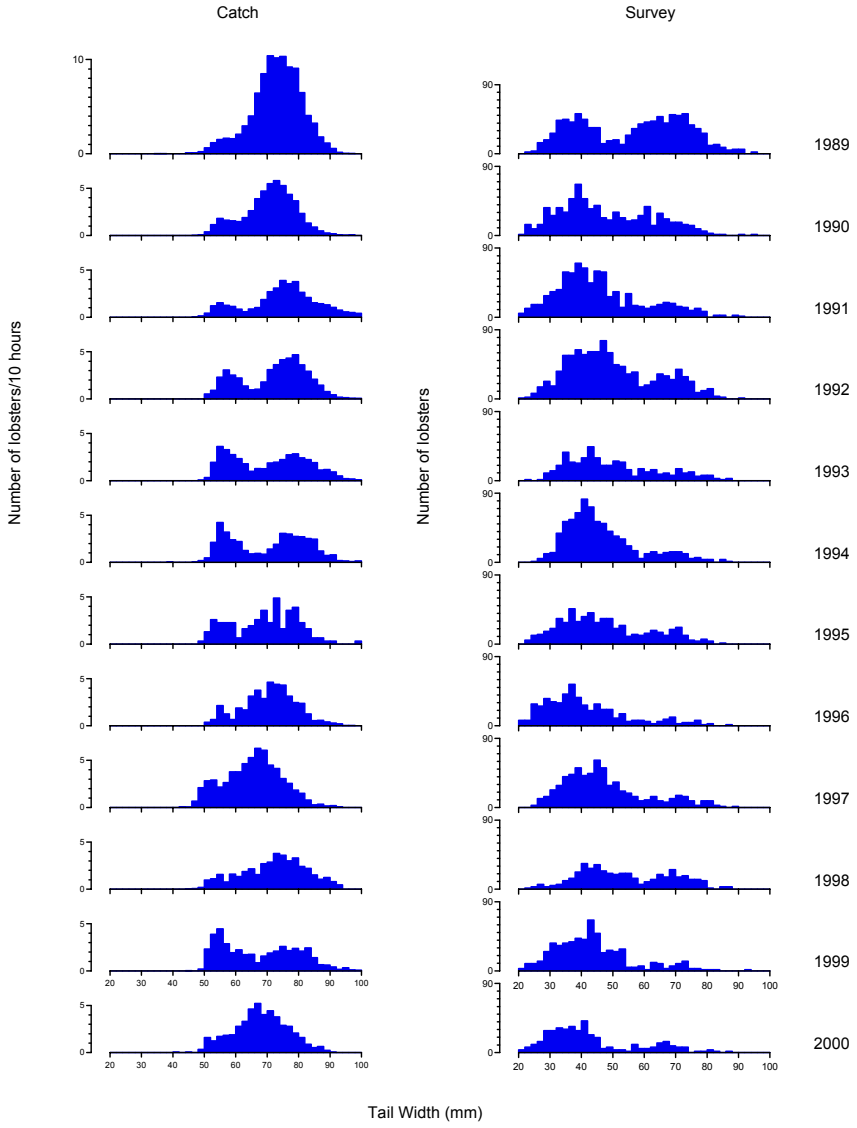

Fig. 2. The size-frequency distributions of the lobster catch landed at Mabuiag/Badu Islands in June/July 1989-2000, contrasted with the size-frequency distribution of the Torres Strait lobster population surveyed by research divers. The graphs are scaled by the CPUE of the fishery and the survey respectively to indicate interannual differences in relative abundance.

The 2000 lobster stock was the second smallest ever recorded

The 2000 2+ year-class was the second smallest recorded to that date, and was only 25% more abundant than the previous record low in 1999 (Figs. 3 & 4). The low stock abundance was not expected at TSFSAC#34 because the 1999 1+ year-class was among the largest recorded (Fig. 3). Mean numbers of 2+ lobsters per site were significantly different (Single treatment ANOVA, $p<0.001$) between years 1990-2000 (Fig. 4). The low abundance of 2+ lobsters was evident in all quadrants, although 2 + abundance in the SW was

similar to the long-term average. The unexpected low 2000 stock, given the above average 1999 recruiting year-class suggests that natural mortality during 1999/00 was very high. The updated fishery model developed by CSIRO estimated natural mortality at about 75% (M=1.478), in contrast to the more typical 60% . The cause of this high natural mortality was likely related to habitat change, particularly a widespread seagrass dieback (similar to that documented in 1992/93) that was reported by fishers and observed by CSIRO.

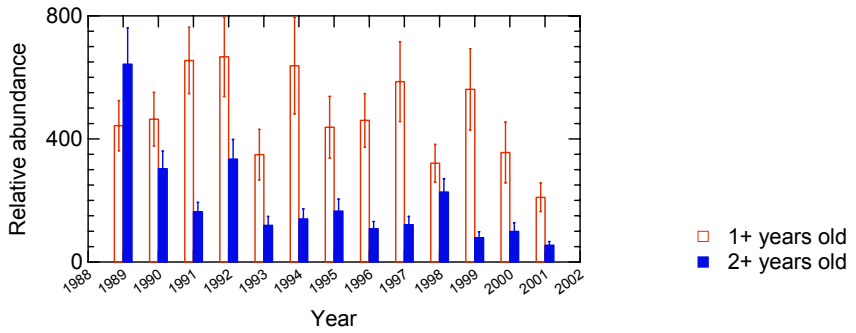

Fig. 3. Numbers of 1+ (open bars) and 2+ (solid bars) lobsters seen during annual surveys of the Torres Strait lobster population between 1989 and 2001. Error bars represent standard errors.

As a result of the low recruit and stock abundance, the combined Aust/PNG catch for 2000 (205 t) was similar to the low 1999 catch (214 t) (Fig. 5).

The 2000 recruiting year-class was similar to the lowest ever recorded

The 2000 recruiting year-class was similar to the lowest ever recorded in 1993 and 1998, and was only 63% of the previous year's level. Mean numbers of 1+ lobsters per site were significantly different (Single treatment ANOVA, $p<0.01$) between years 1990-2000 (Fig. 4). The abundance of 1+ lobsters decreased in all quadrants of the fishery, although the abundance in the NW quadrant was similar to the long-term average (Fig. 4). This low recruit abundance across all quadrants was not anticipated given the above average 1998 stock (and presumably breeding population also). It is possible, given the high mortality of 1999 1+ recruits that settling 0+ lobsters also suffered high mortality in 99/00, as a result

of habitat change. The large 1999 1+ year-class contrasts with the low recruitment in 2000 and the record low in 2001 and indicates the variability in recruitment. It is highly likely that recruitment in 2002 will continue the downward trend, given that the 2000 stock was just greater than the 1999 level.

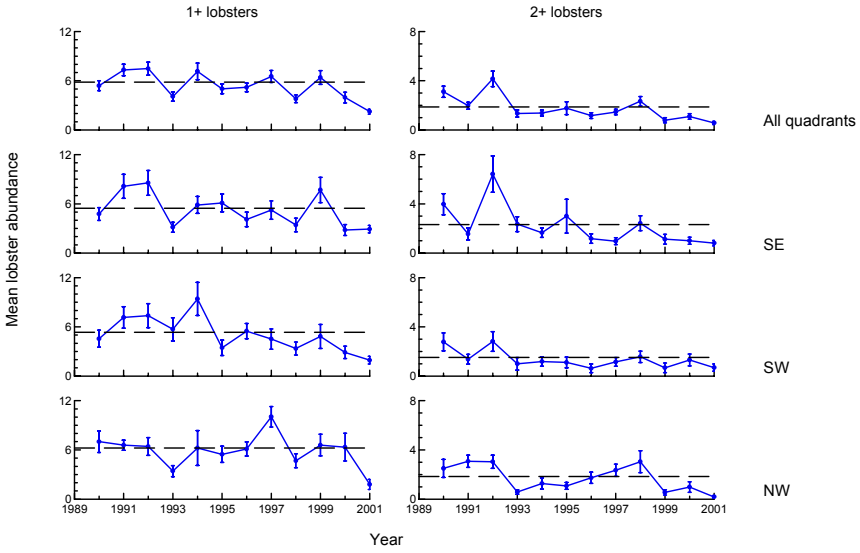

Fig. 4. Mean numbers of 1+ and 2+ lobsters per site in 3 quadrants of the fishery and all quadrants combined between 1990 and 2001 showing spatial and temporal differences in abundance of the 2 year-classes. Error bars are standard errors. The 12 year averages are indicated by the dashed lines.

As in previous years, data on the mean sizes of 1+ and 2+ lobsters highlighted the temporal and spatial differences in growth of lobsters, as well as the differences in growth between the sexes (Fig. 6). These differences are likely caused by a combination of factors including water temperature, food availability and density dependant factors. Recruiting 1+ lobsters in the NW quadrant were significantly smaller than in previous years, likely as a result of the habitat changes reported by fishers. As a result the catch per unit effort of 1+ year old lobsters in the NW quadrant was the lowest ever recorded. However, fishers at Badu/Mabuiag Islands were able to maintain catch rates by taking a much higher percentage (96%) of 2+ lobsters than in previous years. In contrast to the 1+ lobsters, mean size of 2+ lobsters in the NW quadrant was similar to the long-term average, suggesting larger lobsters were not as adversely

affected by the habitat changes.

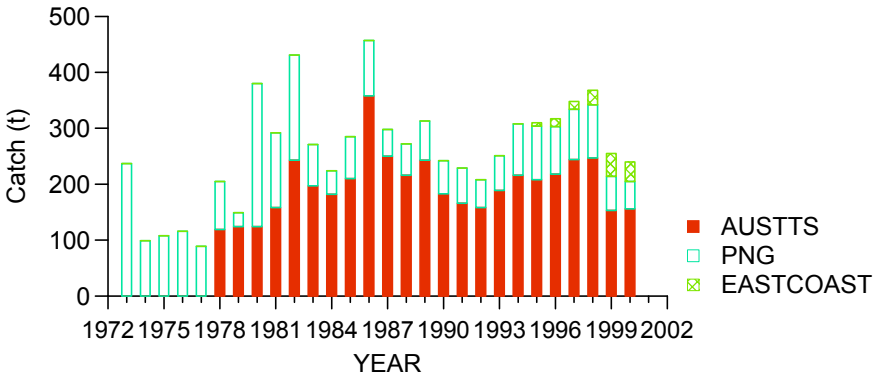

Fig. 5. Commercial lobster catches taken by the Australian, PNG and East Coast sectors between 1973 and 2000. Catches are in tonnes tail weight. Source: AFMA.

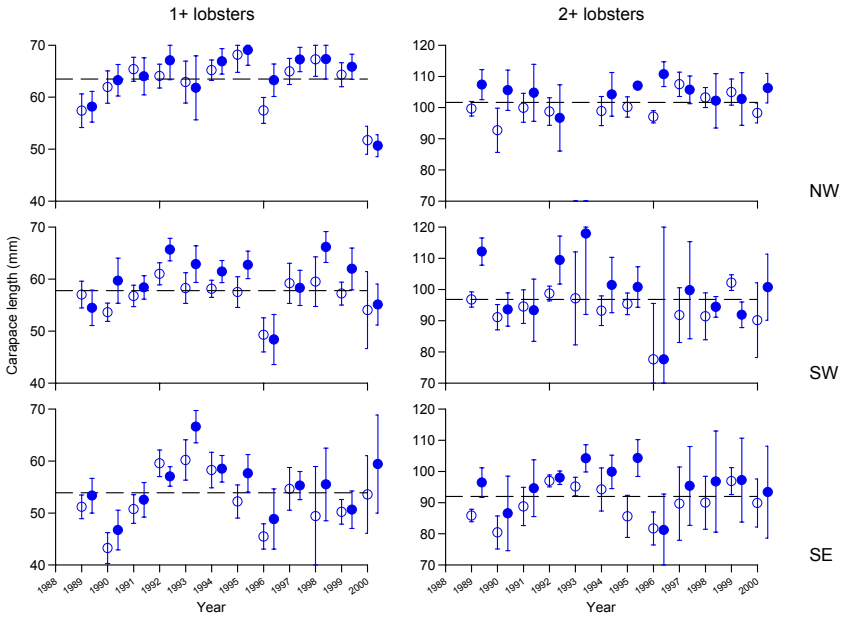

Fig. 6. Mean size of male (circles) and female (filled circles) 1+ and 2+ lobsters caught in 3 quadrants of the fishery (see Fig. 1) between 1989 and 2000, showing spatial and temporal differences in size of the 2 year-classes. Error bars are standard errors. The 12 year averages are indicated by the dashed lines.

2001 Annual Survey Update

The twelfth annual survey of the Torres Strait lobster population was conducted during June 2001 by 4 CSIRO staff, using the vessel R. V. James Kirby. As in previous years, lobsters were counted at 82(formally 100) of the original 572 sites.

The 2001 2+ year-class was the lowest ever recorded, only 70% of the previous record low in 1999 (Fig. 3). This low abundance was foreshadowed, given that the 2000 1+ year-classabundance waslow, similar to the record low in 1998. Fishers and processors corroborated the very low abundance of 2+ lobsters in 2001. Commercial catch data from the Islander Catch Monitoring project had not been analysed at the time of reporting but most islander divers suggested fishing was not economically viable due to the scarcity of legal-size lobsters.

The very low stock abundance was evident in all quadrants of the fishery, although in the SW the 2+ abundance was not significantly lower than levels since 1993.

The 2001 1+ year-class was the lowest ever recorded, only 65% of the previous record low in 1998 (Fig. 3). This low abundance was foreshadowed at TSFSAC #32 as a result of the low stock abundance and hence breeding population in 1999. Most of the decline was evident in the NW and SW quadrants where abundances were record lows. In the SE quadrant the 1+ year-class was similar to the low 2000 level. Consequently, the 2002 fishable stock and total catch are likely to be smaller than the low 1999/2000 levels.

Islander Catch Monitoring

The thirteenth annual islander-catch monitoring program was completed in July 2000. Catch per unit of effort (CPUE) of the island-based fishery was monitored by AFMA staff over 4 weeks at the Northern Star Seafoods processing facility on Badu Island. This information is necessary for several reasons: this sector of the fishery is not monitored by any other means and there are differences between this sector and the freezer boat sector that is monitored by AFMA logbooks, ie. the Islander based sector comprises a significant free-diving component and it is susceptible to local depletion as it lacks the mobility of the freezer vessel fleet. The catch monitoring also provides fishery size-frequency data that is required to estimate the recruit-selection curve for stock assessment modelling.

The CPUE data collected by AFMA is also important because it is collected by independent observers with a high resolution, and concurrent length-frequency data is also collected which enables the calculation of separate CPUE measures for the 1+ and 2+ components of the catch and measures of proportional fishing mortality by size-class.

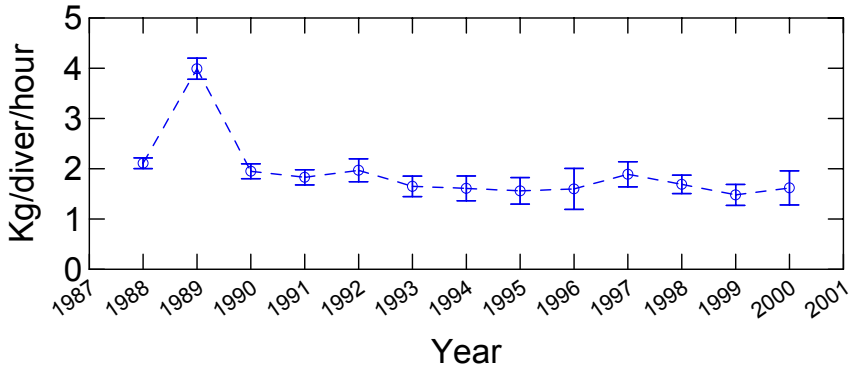

Fig. 7. Least squares means of CPUE (Kg/diver/hour) data from Badu/Mabuiag Islands between 1988 and 2000 (error bars are standard errors).

The overall catch per unit effort (CPUE) of the island-based fishery in mid-2000 (1.62 kg/diver/hr) was similar to the average since 1990 (1.71 kg/diver/hr) (Fig. 7). The island-based CPUE has been extremely consistent since 1990, ranging by only 30% (1.48-1.95 kg/diver/hr), even though stock levels have varied widely (>400%) in the same years. This is particularly evident when comparing catch rates in 99/00 with the catch-rate in 1998. This suggests that fishers are efficient at compensating for low stock levels. However, as reported previously the consistent catch-rate is probably due to changes in fishing behaviour, such as restricting diving to peak times. The consistency in the catch-rates highlights the need for caution when using CPUE as a proxy for abundance.

Contrasting with the previous year (1999), the proportion of 1+ lobsters, relative to 2+ lobsters in the catch was a record low (4%, Fig. 8). This contrasts with previous years of low stock abundance (1993,94, 99) as fishers generally take greater proportions of 1+ lobsters when 2+ lobsters are less abundant, to sustain catch rates. It is likely that the low percentage of 1+ lobsters taken in 2000 was due to the relatively small size of recruiting lobsters (Fig. 6).

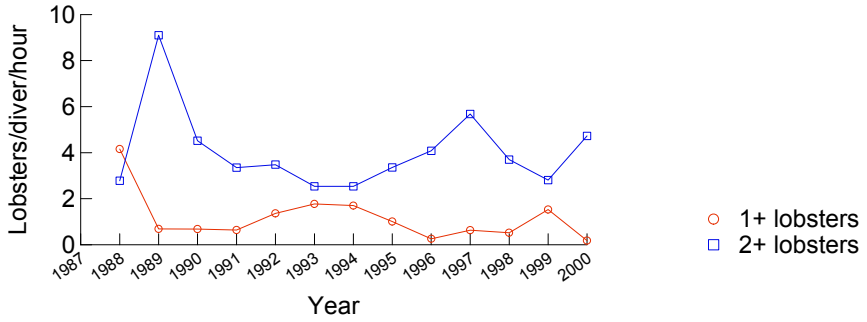

Fig. 8. Catch (number of lobsters) per hour of effort of 1+ and 2+ lobsters caught by divers at Badu/Mabuiag Islands between 1988 and 2000.

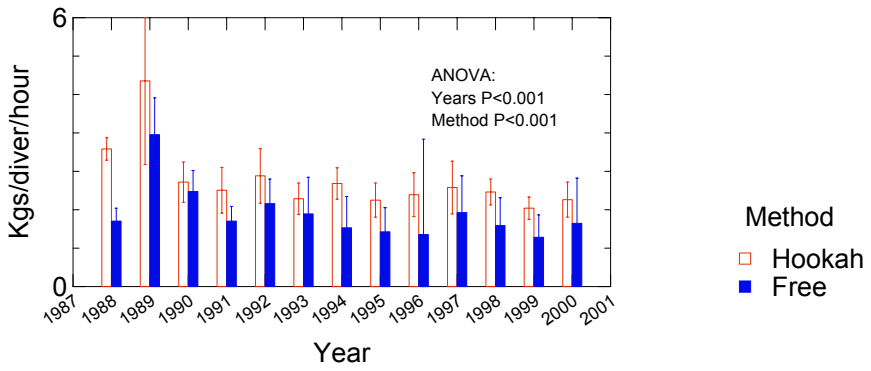

Fig. 9. The catch of lobster (kgs) per hour of effort for Torres Strait hookah divers (open bars) and free divers (solid bars) based at Badu/Mabuiag Island (error bars are 95% C.I.). The result of two-way ANOVA (year by method) is shown.

As in all previous years, the CPUE of hookah divers (1.94 kg/diver/hr) was higher than for free divers (1.41 kg/diver/hr; Fig. 9), but the difference in catch-rates between these methods is not widening. The long-term difference between hookah and free-diver catch rates is 46%. The proportion of fishers free-diving has increased significantly in recent years likely due to the low stock abundance and the need to reduce daily costs such as the hire of hookah equipment.

Continuing the overall trend observed since the annual surveys began there was a general agreement for 2+ lobster abundance between the CPUE of the 2+ lobsters in the catch and the number of 2+ lobsters seen during the annual surveys (Fig. 10). However, there was a disproportionate increase in CPUE between 1999 and 2000, and it is likely fishers increased their catch-rates by restricting fishing to peak times.

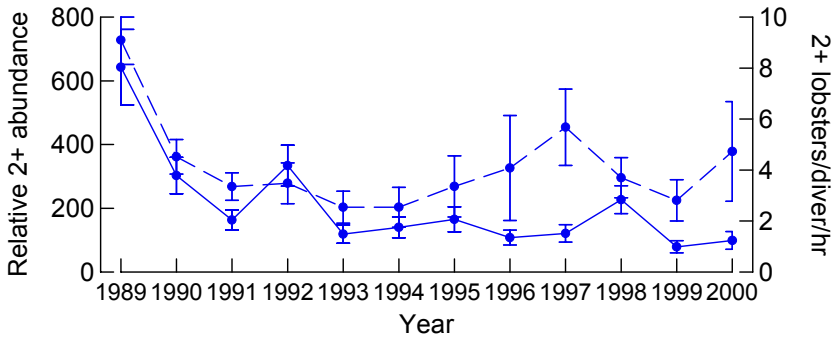

Fig. 10. Comparison of the CPUE of the 2+ lobsters in the Islander catch (dashed line), and the survey abundance of the 2+ lobsters (continuous line).

Stock Assessment

Data collected in the field research sub-projects continues to be synthesised to provide stock status assessments for management. Following the recommendations of the Tropical Rock Lobster Fishery Assessment Group Workshop (TRLFAG) held in March 2000 the stock assessment model has been refined to become a dynamic model and allow status of the fishery to be assessed relative to Biological Reference Points, taking into account known uncertainties by incorporating confidence limits around parameters from the annual surveys. The updated fishery model was presented and appraised at the 6th International Conference on Lobster Biology and Management in September 2000.

The information available for the Torres Strait rock lobster fishery at the time of the TRLFAG indicated that the stock was possibly biologically over-exploited and that management action should be taken to ensure that fishing mortality did not increase, particularly unless further targeted research indicated otherwise. The research activities that were initiated included: abundance surveys consistent with previous surveys undertaken in June 2000 and June 2001; data collection and verification practices upgraded to ensure that the catch data available for assessment purposes represents the total

Torres Strait lobster catch and the status of the fishery assessed relative to Biological Reference Points, taking appropriate account of known uncertainties.

Information from the annual population surveys up to 2000 suggested that recruitment levels in the subsequent 3 years (2001-2003) would be very low. The 1999 lobster stock was the lowest recorded at that time, consequently the 1999 egg-production was likely to be low, leading to a pessimistic outlook for subsequent recruitment in 2001. The natural mortality of lobsters over 1999/2000 was unusually high (only ~25% survival, cf. an average of ~ 40%), probably due to an extensive seagrass die-back in North Western Torres Strait. As a result, the 2000 lobster stock was also very low leading to a pessimistic outlook for subsequent recruitment in 2002.

Recruitment in 2000 was the second lowest recorded and this, combined with the ongoing effects of the dieback meant there was a high likelihood of a poor stock in 2001 leading to a pessimistic outlook for subsequent recruitment in 2003.

Updated dynamic stock assessment modelling of the fishery confirmed that the lobster stock was over-exploited. The 'Maximum Sustainable Yield (MSY) and thus the Maximum Economic Yield (MEY) had been exceeded. The stock was fished down by excessive catches through the 1990's and the recent average Fishing Mortality (F) was F~0.28 (Fig. 11), whereas a sustainable level is around F<0.21.

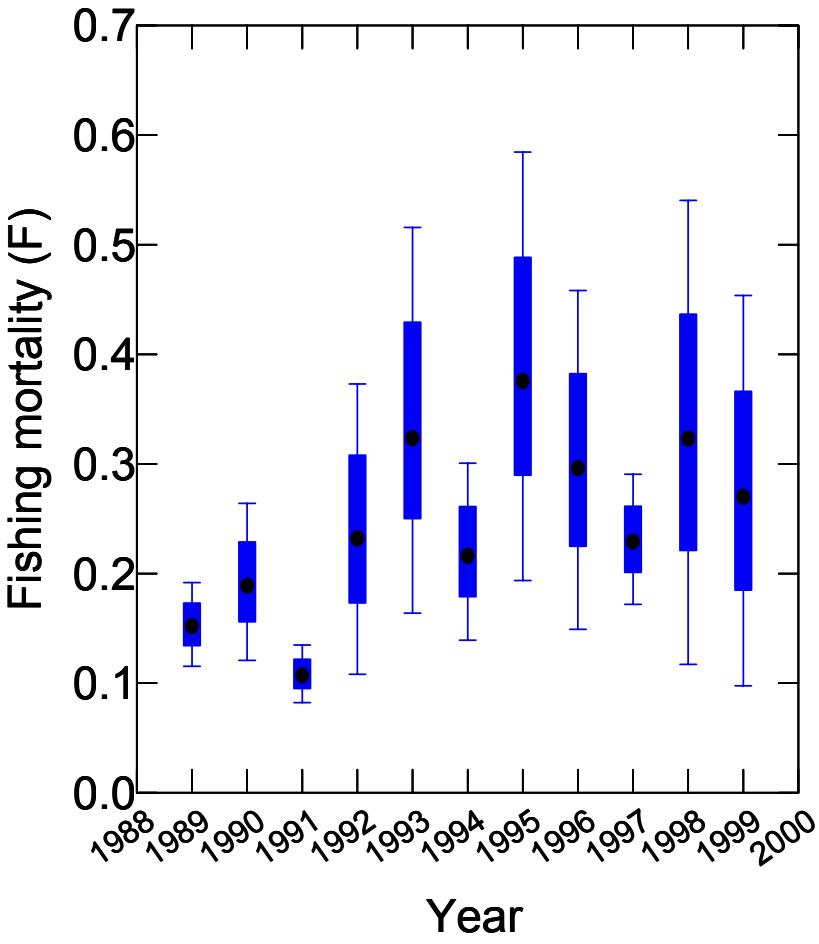

Fig. 11. Estimates of fishing mortality for the Torres Strait lobster fishery between 1989 and 2000 calculated using the updated fishery model. Error boxes & bars represent ±1×SD & ±2×SDs for each mean estimate.

The updated fishery model showed that the fishery is at significant risk relative to the key 'not-to-be-exceeded' Biological Reference Points based on the Stock-Recruitment Relationship (Fig. 12). The current status of the fishery was assessed relative to the indicator stock size ($B_{50\%}$) that produces half the maximum theoretical recruitment ($R_{50\%}$) and the fishing mortality associated with this point ($F@R_{50\%}$). Currently the probability that future recruitment is less than $R_{50\%}$ is ~40-70% and the probability that future stock is less than $B_{50\%}$ is ~40-70%. Assuming no increase in effort the probability that future fishing mortality will exceed $F@R_{50\%}$ is ~25-40%. However, if effort increases, these risks and that of failed recruitments & stocks increase dramatically.

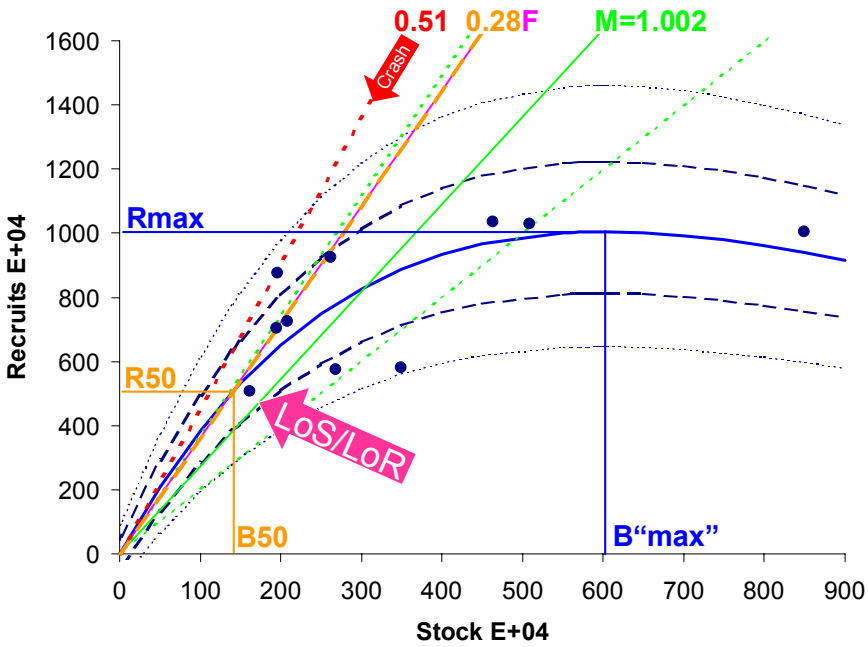

Figure 12. The Stock-Recruitment Relationship for the Torres Strait Lobster Fishery, with Biological Reference Points. The data points are the 2+ year-class (stock year) and 1+ year-class (recruits 2 years later) estimates obtained from the annual fishery-independent dive surveys; the curves indicate the Ricker (r^2=0.72) model ±1×SD and ±2×SD; and the lines indicate the recruit-to-stock mortality for natural mortality (M~1.002±SD) plus current fishing mortality (F~0.28), which coincides closely with F@$R_{50\%}$. Fcrash, the fishing mortality at which the equilibrium stock is zero, and the lowest observed stock and recruitment (up to yr 2000) is also indicated.

Given the high probability that future fishing mortality would exceed F@$R_{50\%}$ several management measures that could be implemented quickly were evaluated for their effectiveness, using the updated fishery model. Increasing the current minimum size (Ls) was seen as one of the most effective measures. Increasing Ls in the range 100-120 mm tail length reduces risks to stock and recruitment. By increasing Ls to 115 mm TL, the probability that future recruitment is less than $R_{50\%}$ is ~15-40% (Fig. 13) and with Ls = 115 mm TL, the probability that future stock is less than $B_{50\%}$ is ~15-35%. By increasing Ls to 115 mm TL, the probability that future fishing mortality is greater than F@$R_{50\%}$ is ~0-3%. Provided there is no increase in effort, future recruitments and stocks would likely be higher and fishing mortality may be F ~ 1.1 to 1.6 with the increased minimum size. Further, by increasing the minimum size

and with current effort, future catch may be slightly greater than if no action is taken.

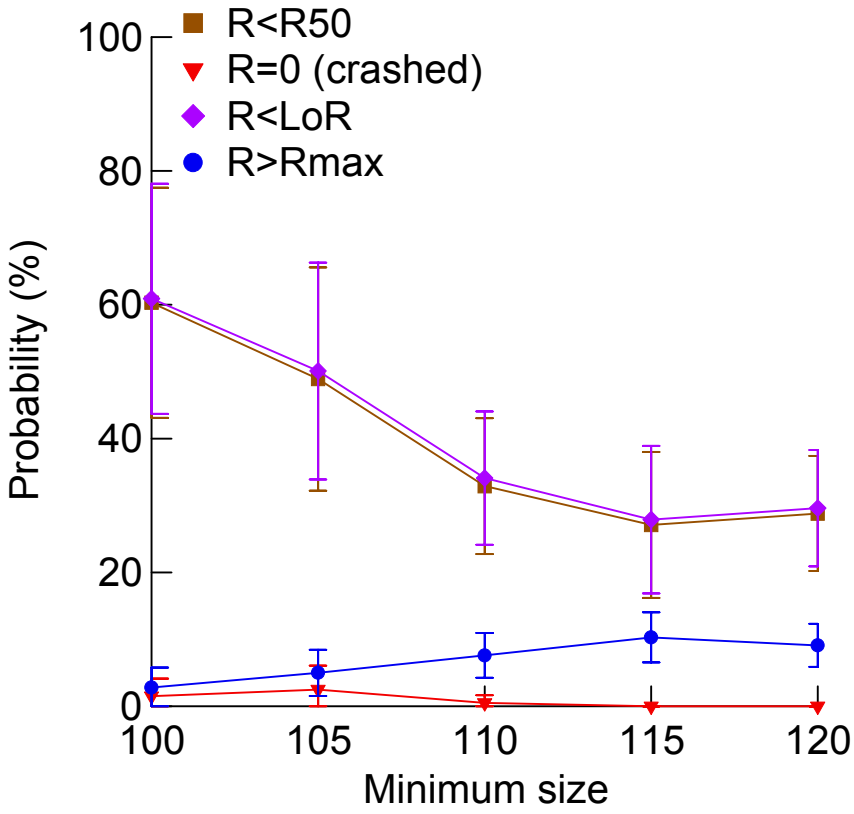

Figure 13. Estimates from the updated fishery model of the probability that Recruitmant Reference Points will be exceeded by the Torres Strait lobster fishery for five minimum tail lengths (mm).

Increasing the closed season on hookah from Oct-Nov to Oct-Dec and Oct-Jan has little apparent benefit unless Ls is also increased. However, the Oct-Jan closed season has a slight benefit when combined with Ls = 115 mm TL and is a popular option among many Islander fishers.

Implementing Ls = 115 mm TL and an Oct-Jan closed season has the immediate benefit of reducing fishing mortality to sustainable levels with the current level of participation in the fishery. However, the fishery is very unlikely to recover quickly in the short term (note pessimistic outlooks above), and may take at least 3-9 years to recover to the projected levels of stock and recruitment.

There is very substantial latent potential effort that may enter the fishery as it recovers, thus negating a full recovery. Thus, the issue of controlling total effort in the fishery must also be addressed as soon as possible. The removal of latent effort and capping of total effort also require the issue of allocation to be addressed at the same time.

Consideration should be given to encouraging the live fishery because it adds value to what is currently discarded (the head, which is ~60% of the lobster weight). Catch rates for live lobsters may be somewhat lower than spearing for tails, nevertheless prices paid for whole live lobsters per kg are similar to those for tails per kg, suggesting that the value of the fishery could be maintained catching 60% fewer lobsters.

Publications from the Project

Bell, R.S., Phillips, B.F., Prescott, J.H. (1986) Migration of the ornate rock lobster, *Panulirus ornatus*, in Torres Strait and the Gulf of Papua. pp. 190-199 In "Torres Strait Fisheries Seminar, Port Moresby, 11-14 February 1985". (Eds A. K. Haines, G. C. Williams, and D. Coates.) (Australian Government Publishing Service: Canberra.)

Bell, R.S., Channells, P.W., MacFarlane, J.W., Moore, R., Phillips, B.F. (1987). Movements and breeding of the ornate rock lobster, *Panulirus ornatus*, in Torres Strait and the northeast coast of Queensland. *Aust. J. Mar. Freshw. Res.* **38**:197-210

Dennis, D.M., Pitcher, C.R., Skewes, T.D., Prescott, J.H. (1992). Severe mortality of breeding tropical rock lobsters, *Panulirus ornatus*, near Yule Island, Papua New Guinea. *J. Exp Mar. Biol. Ecol.* **162:** 143-158.

Dennis, D.M. and Munday, B.L. (1994). Microsporidiosis of palinurid lobsters from Australian waters. *Bull. Eur. Ass. Fish. Pathol.* **14(1)**: 16-18.

Dennis, D.M., T.D. Skewes, C.R. Pitcher (1997). Habitat use and growth of juvenile ornate rock lobsters *Panulirus ornatus* (Fabricius, 1798) in Torres Strait, Australia. *Mar. Freshwater Res.* **48**: 663-670.

Dennis, D.M, Pitcher, C.R, Skewes, T.D. (2001). Distribution and transport pathways of Panulirus ornatus (Fabricius, 1798) and Panulirus spp. larvae in the Coral Sea, Australia (in press). Mar. Freshwater Res. **52**.

Dennis, D.M. and Pitcher, C.R. (2001). Shelter preferences of newly –settled *Panulirus ornatus*. *Lobs. Newsl.* **14(1)**: 6-7.

Joll, L.M., Phillips, B.F. (1986) Foregut contents of the ornate rock lobster *Panulirus ornatus*. pp. 212-217 In "Torres Strait Fisheries Seminar, Port Moresby, 11-14 February 1985". (Eds A. K. Haines, G. C. Williams, and D. Coates.) (Australian Government Publishing Service: Canberra.)

Pitcher, C.R. (1991). Research for sustainable development of the tropical rock lobster fishery in Torres Strait. Proc. Torres Strait Baseline Study Conf., *GBRMPA Wkshp. Ser.* **16**:253—260

Pitcher, C.R., Dennis, D.M., Skewes, T.D., Prescott, J.H. (1991). Catastrophic mortality of breeding tropical rock lobsters. Proc. 1990 Intl. Crust. Conf.: *Mem. Qld. Mus.* **31**:397

Pitcher, C.R., Skewes, T.D., Dennis, D.M., Prescott, J.H. (1992). Estimation of the abundance of the tropical rock lobster, *Panulirus ornatus*, in Torres Strait, using visual transect survey methods. *Mar. Biol.* **113**:57—64

Pitcher, C.R., Skewes, T.D., Dennis, D.M., Prescott, J.H. (1992). Distribution of seagrasses, substratum types & epibenthic macrobiota in Torres Strait, with notes on pearl oyster abundance. *Aust. J. Mar. Freshw. Res.* **43**:409-419

Pitcher, C.R. (1993) Chapter 17: Spiny lobster. pp. 543-611 In *Inshore marine resources of the South Pacific: information for fishery development and management*. (Eds. A. Wright and L. Hill) FFA/USP Press, Fiji

Pitcher C.R., T.D. Skewes, D.M. Dennis (1995). Biology and

fisheries ecology of the ornate rock lobster in Torres Strait. In: O. Bellwood, H. Choat and N. Saxena (eds), Recent Advances in Marine Science and Technology '94. James Cook University of North Queensland, Townsville. pp 311-321.

Pitcher, C.R., D.M. Dennis, T.D. Skewes (1997). Fishery-independent surveys and stock assessment of *Panulirus ornatus* in Torres Strait. *Mar. Freshwater Res.* **48**: 1059-1067.

Prescott, J.H., Phillips, B.F., Bell, R.S. (1986). Rock lobster research in Torres Strait. *Aust. Fish*. **45**(1):2-4

Prescott, J. Pitcher, R. (1991). Deep water survey for *Panulirus ornatus* in Papua New Guinea and Australia. *Lobs. Newsl.* **4(2)**:8-9

Salini, J., Rintoul, G., Shaklee, J.B., Phillips, B.F. (1986). An electrophoretic analysis of stock structure in the ornate tropical rock lobster, *Panulirus ornatus*. pp. 218-232 In "Torres Strait Fisheries Seminar, Port Moresby, 11-14 February 1985". (Eds A. K. Haines, G. C. Williams, and D. Coates.) (Australian Government Publishing Service: Canberra.)

Skewes, T.D., C.R. Pitcher, J.T. Trendall (1994). Changes in the size structure, sex ratio and molting activity of a population of ornate rock lobsters, Panulirus ornatus, caused by an annual maturation molt and migration. *Bull. Mar. Sci.* **54**: 38-48

Skewes T.D., C.R. Pitcher, D.M. Dennis (1997). Growth of ornate rock lobsters, *Panulirus ornatus*, in Torres Strait, Australia. *Mar. Freshwater Res.* **48**: 497-501.

Skewes, T.D., D. M. Dennis, C.R. Pitcher, B.G. Long (1997). Age structure of *Panulirus ornatus* in two habitats in Torres Strait,

Australia. *Mar. Freshwater Res.* **48**: 745-750.

Trendall, J.T., Bell, R.S., Phillips, B.F. (1988). Growth of the spiny lobster, *Panulirus ornatus*, in the Torres Strait. Proc. Workshop on Pacific Inshore Fisheries, South Pacific Commission: Noumea,

Trendall, J.T., Bell, R.S. (1989). Variable patterns of den habitation by the ornate rock lobster, *Panulirus ornatus*, in the Torres Strait. *Bull. mar Sci.* **45**:564-573

Trendall, J.T., Prescott, J.H. (1989). Severe physiological stress associated with the annual breeding emigration of *Panulirus ornatus* in the Torres Strait. *Mar. Ecol. Prog. Ser.* **58**:29-39

Turnbull, C.T. (1989). Pleopod cuticular morphology as an index of moult stage in the ornate rock lobster, *Panulirus ornatus* (Fabricius). *Aust. J. Mar. Freshw. Res.* **40**:285-293

MILESTONES — 2000/01

MILESTONES: Annual lobster population survey

Milestone	Achievement criteria	by Date	Status
1/ 2000 survey fieldwork	abundance & size distribution	7/2000	complete
2/ data entry	database	7/2000	complete
3/ calculate stock indices	Progress report to TSFSAC	3/2001	complete

MILESTONES: Islander lobster catch and effort monitoring

Milestone	Achievement criteria	by Date	Status
1/ Catch monitoring fieldwork	catch data	7/2000	complete
2/ Data entered & analysed	database	8/2000	complete
3/ parameter estimates	Progress report to TSFSAC	3/2001	complete

MILESTONES: Lobster stock assessment modelling

Milestone	Achievement criteria	by Date	Status
1. annual collation of data	fishery databases	6/2001	ongoing
2. analysis of available data	population parameters	6/2001	ongoing
3. update/development of stock model	computer model	6/2001	ongoing
4. conduct 2000 stock assessment	Progress report to TSFSAC	3/2001	completed
5. assess 2000 stock status	Annual report to TSFSAC	9/2001	this report

Research for Management of the Ornate Tropical Rock Lobster, *Panulirus ornatus*, Fishery in Torres Strait:

Summary Annual Report to TSFSAC#36; September 2001

The project conducts biological research and stock assessment on the Torres Strait lobster fishery, to provide information and advice to facilitate sound management.

The eleventh annual lobster stock survey to estimate the number of fishable 2+ year old and recruiting 1+ year old lobsters in western Torres Strait was completed in June 2000 by CSIRO staff. The 2000 2+ year-class was the second lowest ever recorded and only 25% greater than the record low in 1999. The low 2+ abundance was not foreshadowed at TSFSAC #34 because the 1999 1+ year-class was among the largest recorded. The low stock abundance was evident in all quadrants of the fishery, although 2+ abundance in the SW was similar to the long-term average. The unexpected low 2000 stock, given the above average 1999 recruiting year-class suggests that natural mortality during 1999/00 was very high. The updated fishery model developed by CSIRO estimated natural mortality at about 60% (M= 1.478). The cause of this high natural mortality was likely related to habitat change, particularly a widespread seagrass dieback that was reported by fishers and observed by CSIRO. The 2000 recruiting year-class was similar to the lowest ever recorded in 1993 and 1998, and was only 63% of the 1999 level. As a result of the low recruit and stock abundance, the combined Aust/PNG catch for 2000 (205 t) was similar to the low 1999 catch (214 t).

The twelfth annual lobster stock survey was completed in June 2001. The 2001 2+ year-class was the lowest ever recorded, only 70% of the previous record in 1999. The 2001 1+ year-class was also the lowest ever recorded, only 65% of the previous record in 1998. This low abundance was foreshadowed at TSFSAC#32 as a result of the low stock, and hence breeding population in 1999. The 2002 fishable stock and total catch are likely to be smaller than the low 199/00 levels.

The thirteenth annual islander-catch monitoring program was completed in June 2000 based at Badu Island. The overall catch per unit effort (CPUE) of the island-based fishery in 2000 (1.62 kg/diver/hr) was similar to the average since 1990 (1.71 kg/diver/hr). However, in contrast to 1999 the CPUE of 1+ lobsters (0.18 lobsters/diver/hr) was the lowest ever recorded, and fishers maintained catch rates by taking a greater percentage (96%) of 2+ lobsters. As in most previous years the catch rate of hookah divers was ~40% higher than that of free divers (1.94 cf. 1.41 kg/diver/hr).

Data collected in the field research sub-projects continues to be synthesised to provide stock status assessments for management. Following the recommendations of the Tropical Rock Lobster Assessment Workshop held in March 2000 the stock assessment model has been refined to become a dynamic model and allow status of the fishery to be assessed relative to Biological Reference Points, taking into account known uncertainties by incorporating confidence limits around parameters from the annual surveys.

Updated dynamic stock assessment modelling of the fishery confirmed that the lobster stock was over-exploited. The stock was fished down by excessive catches through the 1990's and the recent average Fishing Mortality (F) was F~0.28, whereas a sustainable level is around F=0.21. The model showed that the fishery is at significant risk relative to the key 'not-to-be-exceeded' Biological Reference Points based on the Stock-Recruitment Relationship. The current status of the fishery was assessed relative to the stock size that produces half the maximum recruitment (R50%) and the fishing mortality associated with this point (F@R50%). Currently the probability that future recruitment is less than R50% is ~40-70% and the probability that future stock is less than S@R50% is ~40-70%. Assuming no increase in effort the probability that future fishing mortality will exceed F@R50% is ~25-40%. However, if effort increases, these risks and that of failed recruitments & stocks increase dramatically.

Given the high probability that future fishing mortality would exceed F@R50% several management measures that could be implemented quickly were evaluated for their effectiveness, using the updated fishery model. Increasing the current minimum size (Ls) was seen as one of the most effective measures. By increasing Ls to 115 mm TL, the probability that future recruitment is less than R50% is ~15-40% and with Ls = 115 mm TL, the probability that future stock is less than S@R50% is ~15-35%. By increasing Ls to 115 mm TL, the probability that future fishing mortality is greater than F@R50% is ~0-3%. Provided there is no increase in effort, future recruitments and stocks would likely be higher and fishing mortality may be F ~ 1.1 to 1.6 with the increased minimum size. Further, by increasing the minimum size and with current effort, future catch may be slightly greater than if no action is taken.

Increasing the closed season on hookah from Oct-Jan has little apparent benefit unless Ls is also increased, however, the Oct-Jan closed season has a slight benefit when combined with Ls = 115 mm TL and is a more popular option among many Islander fishers. Implementing Ls = 115 mm TL and an Oct-Jan closed season has the immediate benefit of bringing fishing mortality down to sustainable levels with the current level of participation in the fishery. However, the fishery is very unlikely to bounce back quickly in the short term, and may take 3-9 years to recover to the projected levels of stock and recruitment.

There is very substantial latent potential effort that may enter the fishery as it recovers, thus negating a full recovery. Thus, the issue of controlling total effort in the fishery must also be addressed as soon as possible. Consideration should be given to encouraging the live fishery because it adds value to what is currently discarded and prices paid for live lobsters per kg are similar to those for tails per kg, suggesting that the value of the fishery could be maintained catching 60% fewer lobsters.