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Effect of climate parameters on mud crab (*Scylla serrata*) production in Australia

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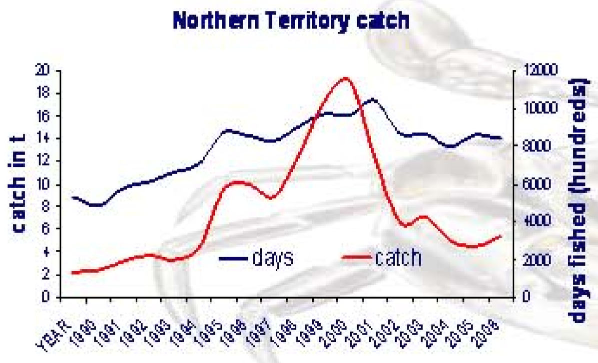
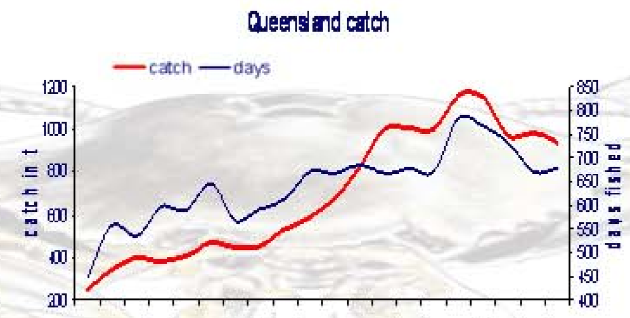
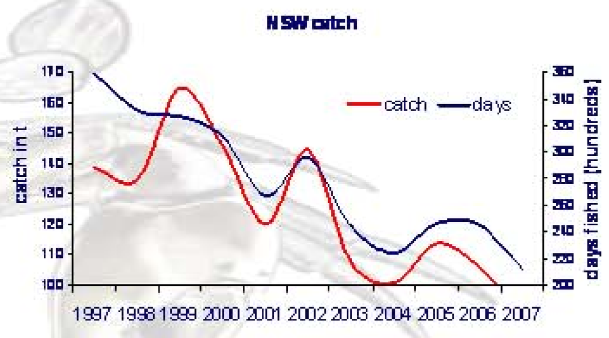
Abstract

The speculation that climate change may impact on fish production suggests a need to understand how these effects influence fisheries catch on a broad scale. Mud crabs (*Scylla serrata*) are a highly valued commercial species and the demand as well as their catch rates have increased continuously over the past decade in many parts of Australia. *Scylla serrata* has lifecycles related to rainfall and temperature patterns but a quantification of the link is yet to be undertaken. The difficulty involved in explaining the effect of climate driven parameters arising from limited knowledge of the species biology may be overcome by relating climate parameters with long-term catch data for specific regions. Transformed catch per unit effort (CPUE), freshwater flow and sea surface temperature and catch time series for specific combinations of time intervals and estuaries have been explored using correlation analysis. Correlation of catches of mud crab catch (*Scylla serrata*) with rainfall suggests that rainfall and temperature thresholds exists and if exceeded can cause loss of production. This fishery may therefore be sensitive to effects of climate change. The most significant relationships between mud crab catch, rainfall and temperature were detected for South-East Australia with a trend to weaker relationships towards the north. However, catches lagged by 2 years in the tropical north showed a distinct relationship with freshwater flow events which was also supported by meta-analysis.







Preliminary Results

Significant Pearson correlation were identified for the southern regions of Queensland between catch, sea surface temperature and rainfall; and for the Northern Territory with SOI values and catches.

Table 1: Significant Pearson correlation coefficients (r) between commercial mud crab catches, rainfall and sea surface temperature (**bold**) in Queensland. Categories: averaged monthly catch, based on 1988-2004 data (n = 12), annual catch based on 1988-2004 data (n = 17), monthly catch, based on 1988-2004 (n = 204) (* P < 0.05; ** P < 0.01). NP = North Peninsula, SP = South Peninsula, BNC = Barron North Coast, HNC = Herbert North Coast, ECC = East Central Coast, PSC = Port Curtis South Coast, MSC = Moreton South Coast.

Catch	LC	NP	SP	BNC	HNC	ECC	PSC	MSC	N
Seasonal	.72**	-.74**	-	-	-	**.61*/** .69*	**.80**/** .70**	**.85**/** .86**	12
Seasonal kg d-1	-	-		-	.63*	.63*	**.75**/** .62*	**.77**/** .80**	12
Monthly	-.18**	**-.23**/** -.24**	-	-	**.20**/** .19**	**.46**/** .19**	**.59**/** .22**	**.68**/** .29**	204
Monthly kg d-1		-.18*	.14*	-	**.25**/** .22**	**.43**/** .26**	**.50**/** .19**	**.64**/** .34**	204

Table 2: Suggested production models by CLIMPROD (FAO, 1998) including rainfall based on Qld. catch from 1988-2004. The MSY for mud crabs may be overestimated due to a constant increasing effort. CPUE is landing per unit effort kg/days/year; *E* is fishing effort; *V* is annual rainfall, and *a*, *b*, *c* are constants. The MSY was estimated by the median of the MSY.

Species	Conventional r^2	Jackknife r^2	MSY in t (± SE)	CPUE model	Modification
Mud Crab	0.87	0.75	221 (± s.e. 63)	a+b.V+c.E	exploited year classes 3

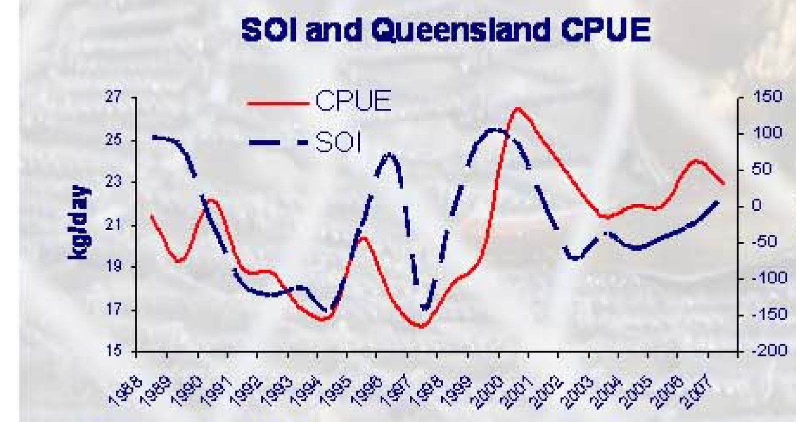


Fig. 1. SOI values and Queensland mud crab catch (kg/day) showed a significant Pearson correlation (r = 0.50) with a 2 and 3 year lag.

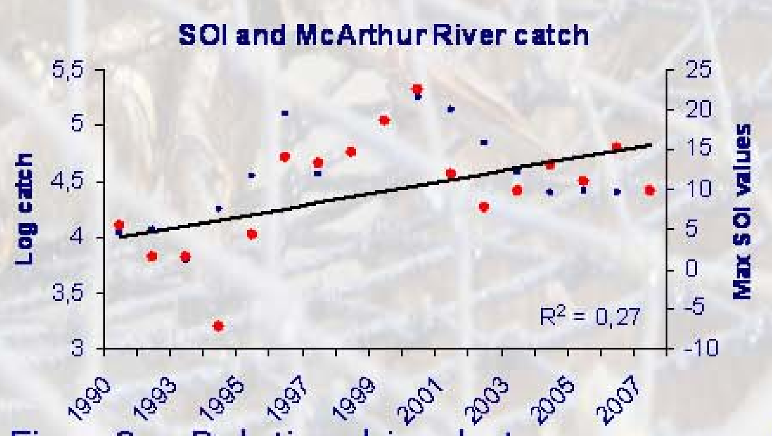


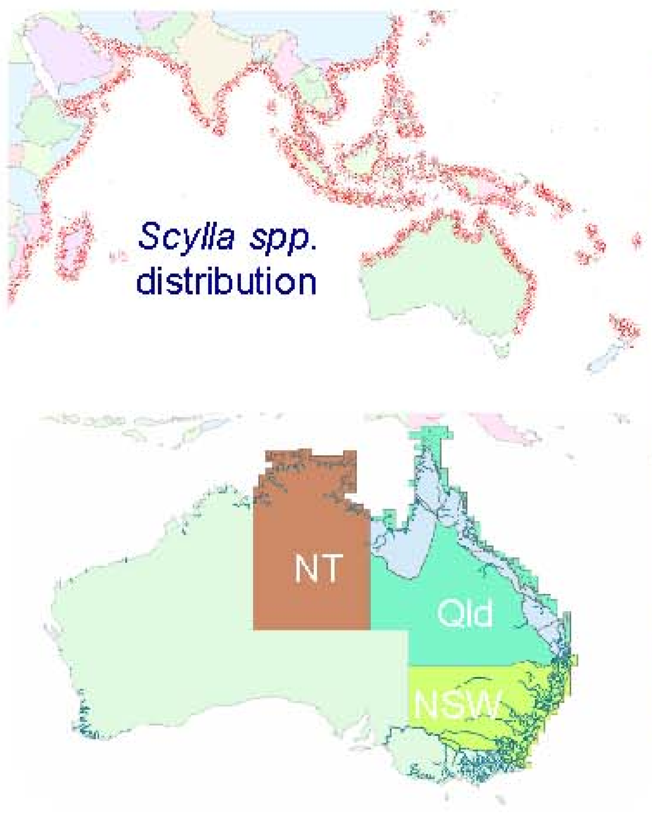
Fig. 2. Relationship between annual maximum SOI values as an indicator for a strong monsoon and log transformed mud crab catch for the McArthur River which contributes up to 50% to the total catch in the Northern Territory.

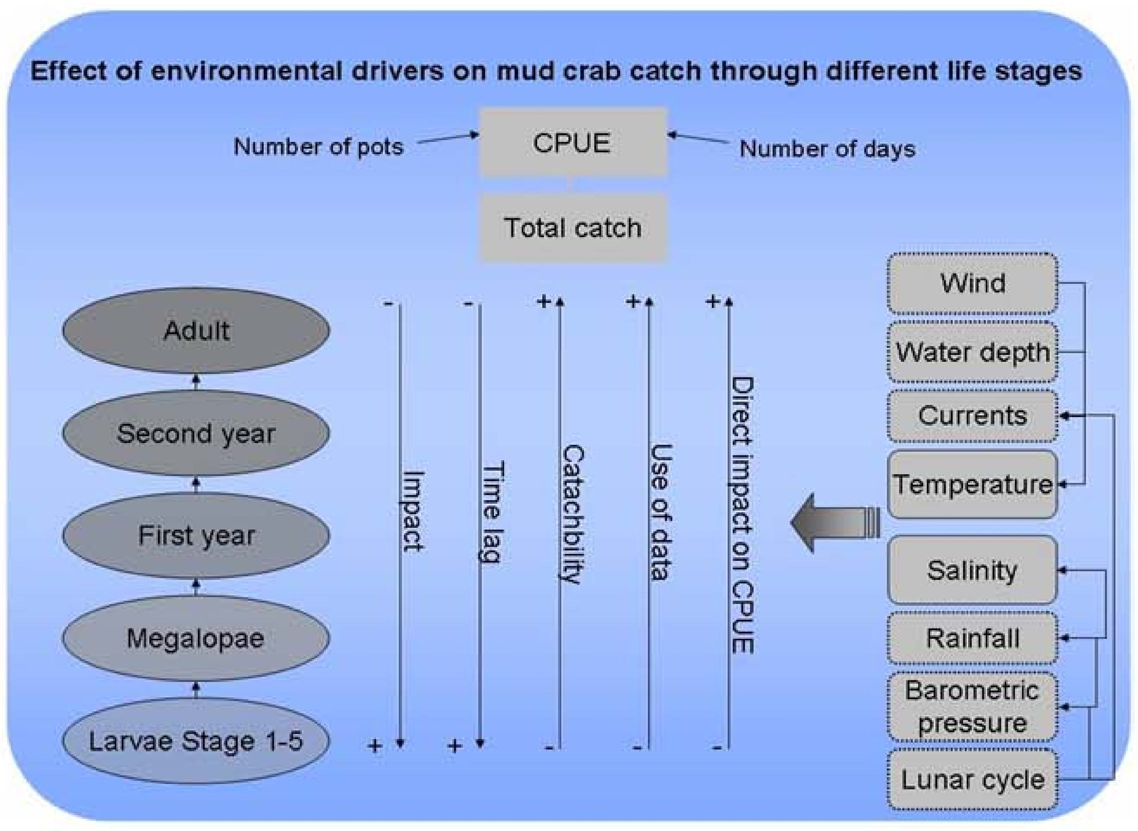
Methodology

Model:
There is evidence that temperature and salinity function as the major environmental drivers on different life stages of mud crabs (Hill, 1974).Related to temperature are physical parameters such as wind, water depth and currents (lunar cycle) which themselves can influence the different life stages of mud crabs and the catch rates. Salinity is influenced by rainfall and rainfall by barometric pressure. The direct impact of environmental driver on catch per unit effort increases with the life stage similar to the use of data (temp and catch data) and the catchability also increases with age. In contrast the impact of environmental drivers on mud crab is highest in their early life stages and the time lag between impact of e. driver and effect on the CPUE decreases with different life stage.

Data:
Data on catch, effort (number of days and pots) for mud crabs based on daily logbook records reported by commercial fishers, and data on annual and monthly sea surface temperature, rainfall and values for the Southern Oscillation Index (SOI) covering the years 1988-2007 (Queensland), 1990-2007 (Northern Territory) and 1997-2007 (New South Wales) were used. For preliminary analyses we concentrated on the McArthur River in the Northern Territory (with the highest catch rates in NT) and 8 coastal districts in Queensland.

Data analyses:
Relationships between catch, temperature, rainfall, and SOI were explored using single linear regression models and correlation analysis. We also used CLIMPROD (FAO, 1998) to estimate a maximum sustainable yield using the catch-rainfall relationship for mud crabs in Qld. Where appropriate data have been lagged (Wilber, 1992) but this was done only when biological meaningful (e.g. age of sexual maturity).





Summary

Finding the most relevant driver:
When investigating the influence of environmental drivers in commercial catch, a number of factors make the analyses difficult. Next to biological parameters (e.g. habitat), the catch data is driven by demand, gear and regulations – generating noise and overlaying trends. However, large scale shifts in the catch of mud crabs interannual fluctuations in in catch of an order of magnitude caused by fishing power are unlikely in a pot-based fishery.

Positive relationships with maximum annual SOI values for the McArthur River in the Northern Territory can be attributed to strong monsoon indicated by high positive SOI values. Such events bring higher temperatures and rainfall. Higher rainfall and hence river flow stimulates the downstream movement of mud crabs (Hill *et al.* 1982) and this could increase the catchability in the lower estuary and bay. The reduction in numbers of subadult and adult crabs in the river systems may also enhance the survival of juveniles because of reduced cannibalism and competition for burrows. Positive correlation between catch and monthly high sea surface temperature in Queensland may increase the activity of crabs and therefore catchability whereas the positive relation of catch with lagged SOI values might be result of better recruitment during warm and wet years.

Improving statistical methods:
- minimising potential effects of spatial autocorrelation by using a subset of estuaries for meta-analysis
- testing for homogeneity of variance and normality underlying the correlation analysis
- reducing the possible number of correlations by selecting parameters which are biologically meaningful
- adjusting for temporal autocorrelation with autocorrelation functions like the modified Chelton method

References

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