The effect of cold water stunning on the survival and growth of caught and returned western rock lobsters (*Panulirus cygnus*)

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Australian Government
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2002/239 The effect of cold water stunning on the survival and growth of caught and returned western rock lobsters (*Panulirus cygnus*).

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Objectives:

1) To determine the effect of capture and cold-stunning on the survival and growth of returned protected western rock lobsters

2) To observe and film in the wild the behaviour of stunned returned western rock lobsters

Non-Technical Summary

Outcomes achieved to date:

The relative recapture rates of returned stunned and unstunned lobsters have been quantified. Apparently conflicting results were obtained from two different areas of the fishery, but the results were deemed inconclusive due to low numbers of recaptures from water surrounding the Southern Group of the Abrolhos Islands.

The behaviours of returned lobsters have been observed underwater. Lobsters spending excessive periods of time in the stun tank at 5-10°C showed delayed recovery following return to the ocean. The findings have prompted a second expanded study to investigate the effect of stun time on lobster recapture rates over a wider geographical area.

Post-harvest leg loss is a significant problem for the western rock lobster industry. Industry estimates suggest that up to 80 tonnes of legs, worth $2-3 million, are lost from the catch each year between the time of capture and receipt at processing factories. Even after catches are landed, additional losses occur during sorting in the factory, live storage, processing, packaging for live export and unpacking at export destinations. Previous studies (FRDC Project 2000/251 and FRDC Project 2002/239) have shown that cold water stunning is an effective and simple method for preventing leg loss in western rock lobsters during post-harvest handling. However, those studies raised questions about the effects of on board cold water stunning on the survival of returned protected lobsters, such as breeding females and undersized.

The present work has yielded apparently conflicting results in different fishing areas. In inshore waters between Dongara and Geraldton, no difference was found in the recapture rates of returned stunned undersized lobsters and those returned to the water without stunning. However in waters surrounding the Southern Group the Abrolhos Islands, stunned lobsters were apparently recaptured at a lower rate than their unstunned counterparts. This latter result was deemed inconclusive due to the

low numbers of recaptures from both groups. Further work is planned to clarify the situation.

Keywords:

Lobster, Autotomy, *Panulirus cygnus*

Acknowledgements

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Background

At the 1998 FRDC Rock Lobster Post-harvest Sub-program Workshop (Hillary's Boat Harbour, WA), post-harvest leg loss was identified by fishers and processors as a significant problem. Post-harvest leg loss impacts upon the profitability and sustainability of the western rock lobster fishery in the following ways: 1) Reduced catch weight; 2) Loss of value/restricted marketing opportunity for damaged lobsters; and 3) Increased mortality and reduced growth and reproductive success of damaged returned undersized and reproductive lobsters. Losses from 1) and 2) are estimated to be $2-3 million/year. Losses arising from 3), are likely to be substantial, and may even exceed that from 1) and 2). In response to this problem, FRDC Project 2000/251was funded to investigate the use of cold water stunning for preventing post-harvest leg loss. The results from this project to date have been very promising. Under the conditions of recent field trials comprising 44 days of fishing and over 5000 pot lifts, cold water stunning was shown to reduce on board leg loss by 80%. In fact, the quality of the catch was improved by every measure: 0.26% increase in catch weight, 5% increase in lobsters delivered to the factory in a condition fit for live export, 11% increase in intact lobsters arriving at the factory with no damage whatsoever (i.e. no missing feelers or missing legs), and a 1.6% decrease in the numbers of lobsters downgraded as fit only for tailing.

When we applied for project 2000/251, our intention was to a) demonstrate the effectiveness of cold-stunning for reducing leg loss (which we have done), then b) examine the effects of cold-stunning on reproductive females and returned undersized in captivity (currently under way), and finally (assuming favourable results up to this point) c) undertake a tag and recapture study in the wild to investigate survival of returned lobsters. Sections a) and b) were funded in 2000/251, but c) (tag and recapture) was not. At the instruction of the Rock Lobster Post-harvest Sub-program Steering Committee, we are applying for a new grant for the tag and recapture work.

Industry has shown significant interest in project 2000/251 and this has been fuelled by the very positive results gathered to date. On the 2001 RLIAC Coastal Tour, a number of fishermen asked if cold water stunning was illegal under the current legislation. The RLIAC Executive Officer, Tim Bray, stated that he did not consider

cold water stunning to be illegal under the legislation. The situation now exists where fishermen may freely implement on board cold-stunning. It is critical therefore, to determine if this practice has any detrimental effect on the fishery so that sound management decisions can be made regarding the use of cold-stunning. The proposed tag and recapture study will provide the ultimate test of whether cold-stunning can be safely applied by the western rock lobster industry

Need

With commercial fishermen already beginning to implement cold-stunning there is a critical need to determine possible impacts of this activity on the returned protected lobsters (breeding females and undersized).

Objectives

1) To determine the effect of capture and cold-stunning on the survival and growth of returned protected western rock lobsters
2) To observe and film in the wild the behaviour of stunned returned western rock lobsters

Methods

Objective 1) To determine the effect of capture and cold-stunning on the survival and growth of returned protected western rock lobsters.

Boat set up and fishing methods

All tagging was conducted aboard the Centralwest College of TAFE training vessel *Lady Tafe*. Prior to this work, *Lady Tafe* was equipped with a fairly standard set up for working lobster gear (Figure 1). A tipper mounted on the gunwale brought pots over the side to rest on a slide rail on the top edge of an aluminium sorting box, or cacka box. For the purpose of the trials a stun tank was placed aft of the cacka box under the slide rail. The stun tank consisted of an insulated bin (490 x 680 x 530 mm; 175 L). Water in the stun tank was cooled to 8 ± 1 °C by a stainless steel coil placed in the tank and connected via flexible lines to a 1.5 hp seawater-cooled chiller unit installed below deck. Power for the chiller unit was supplied by a portable 7 kVa petrol generator placed on the flying bridge. Water in the stun tank was aerated at all times to prevent thermal stratification.

Standard commercial slat lobster pots with closed escape gaps, were baited with fish bait (Summer Herring (*Alosa aestivalis*), Salmon (*Arripis trutta*) heads) and set out on suitable bottom in "lines" of 5-15 pots. The pots were left overnight before being pulled early the following day. Undersized lobsters (sub-76 mm carapace length (CL)) from every second pot were emptied into the cacka box before being measured (CL), tagged dorsally through the arthrodial membrane between the cephalothorax and first abdominal segment using Hallprint TBA-1 tags and an Avery Dennison Mark III tagging gun, inspected for damage to appendages and gender and returned to the ocean (Figure 2 & 3). These lobsters were the controls. The "treatment" lobsters from alternate pots were emptied from the pot into a lug basket (Nally IH 300) submerged in the stun tank, where they remained for between 10-15 secs. after the first lobster entered the stun water. The time varied depending on how long it took for all lobsters to be removed from the pot and ensured that last lobster into the stun tank was submerged for approximately 5 sec. After this time the basket was removed from the stun tank water and all undersized lobsters were tagged, measured and returned to the ocean. Lobsters from each pot were returned to the ocean at the same GPS position where the pot was set. Water depth and GPS position for each pot were recorded. The aim was to tag 2000 lobsters per group in each tagging area.

Figure 1) The set up aboard Lady Tafe used for the cold-stunning tag and release work. The pot tipper is to the right of the picture (hidden). The (blue) stun tank can be seen in the background with the flexible coolant lines to and from the coil visible at the top front edge of the tank.

Previous research has shown that, in western rock lobster, dorsal streamer tags are more likely to be mutilated or shed than ventral streamer tags (Melville-Smith and Chubb, 1997). However, the decision was made to tag lobsters dorsally because commercial lobster fishermen do not check the ventral surface of undersized lobsters before returning them to the ocean. If tags were applied ventrally, many would be missed during on board sorting by fishermen.

The tag and release of western rock lobsters was undertaken in coastal waters (< 15 fms) between 7 Mile Beach and Geraldton in early November 2002 and a second round of tagging was conducted waters surrounding the Southern Group of the Abrolhos Islands in late February/early March 2003 (Figure 4). The two areas were selected primarily because they cover a wide range of predator densities. Predation is likely to be a major cause of mortality of cold-stunned returned lobsters. The timing

of the tagging periods were chosen to ensure that tagged lobsters were released immediately prior to the commencement of the commercial fishing seasons in the two areas. This approach maximised the recaptures of tagged lobsters, thereby increasing the sensitivity of the analyses.

Figure 2) Crew aboard Lady TAFE tagging and releasing lobsters. Note the design of the commercial lobster pots used in the study.

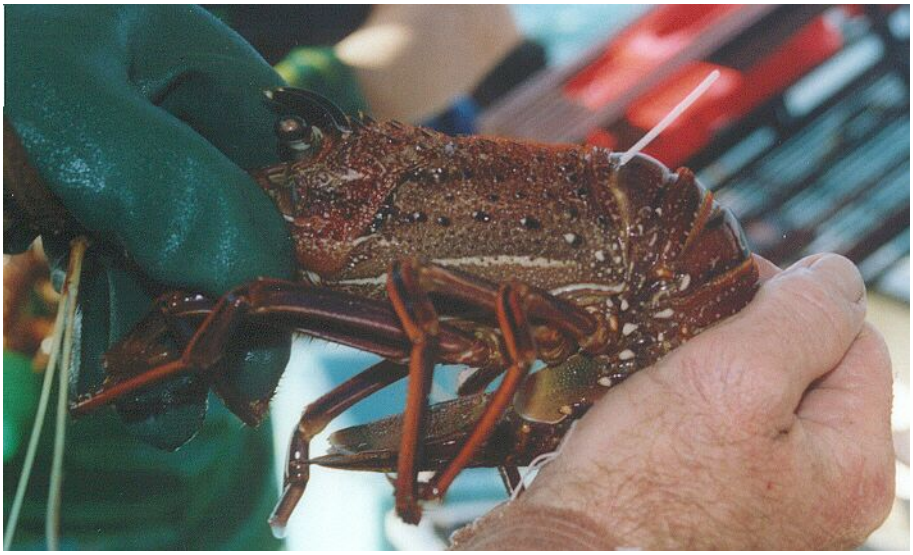

Figure 3) Lobsters were tagged with Hallprint TBA-1 streamer tags. These tags have been used widely by the WA Department of Fisheries in the past.

Figure 4) Lobsters have been tagged in inshore waters between Geraldton and Seven Mile Beach (red oval) and will be tagged at the southern group of the Abrolhos Islands (red circle).

To maximise tag returns, the study was widely publicised using all available media, including industry magazines (*Prowest*), local newspapers, and Geraldton Fishermen's Co-operative internal newsletters.

As an incentive to make accurate returns, the names of all fishermen who return tagged lobsters were entered into a lottery for a $5000 cash prize.

Objective 2) To observe and film in the wild the behaviour of stunned returned western rock lobsters.

The recovery and behaviour of caught and returned lobsters was filmed underwater by SCUBA divers using a Top Dawg II underwater video camera housing and a Sony TRV series video recorder. Information such as, time to first tail flick after entering the water, descent rates, shelter-seeking behaviour and predator-lobster interactions were recorded for later analysis. This filming was undertaken at the Abrolhos Islands where there is excellent visibility and the high density of predators ensured a high probability of observing numerous predator–lobster interactions.

Statistical Analysis

Statistical analysis of all results was performed using the computer packages MSExcel ver. 8.0, SigmaStat ver. 1.01 or JMP ver.3.2.2 for Macintosh. All data are presented as means ± 1 sem.

Results and Discussion

Between 4-16 November 2002, 4038 lobsters were tagged in coastal waters (< 15 fms) between Seven Mile Beach and Geraldton. Of these, 2047 were controls (no stunning treatment) and 1991 were stunned at 8°C for 10-15 sec. before being tagged, inspected, measured and released. Due to difficulties catching enough undersized lobsters to reach the target of 2000 stunned and 2000 control lobsters, 1012 lobsters

greater than 76 mm CL were tagged throughout the tagging period. The largest lobster tagged was 90 mm CL. Tagging of these larger lobsters was justified by the fact that the larger lobsters may give some insight into the effects of cold-stunning on the survival of breeding females (setose, tar spot and berried) that may be returned to the ocean. Forty seven per cent of the legal-sized lobsters tagged were female, although in this case none of them were in breeding condition.

Between 24 February–2 March 2003, 4035 lobsters were tagged in waters surrounding the Southern Group of the Abrolhos Islands (Table 1). Of these, 2057 were controls (no stunning treatment) and 1998 were stunned at 8°C for 10-15 sec. before being tagged, inspected, measured and released. As with the coastal tagging, some legal-sized lobsters were tagged at the islands. In total, 541 legal-sized lobsters (283 control + 258 stunned) were tagged and released. However, unlike the lobsters tagged in coastal waters, the majority of the legal-sized lobsters tagged at the Islands were breeding females. This was to be expected given that lobsters at the islands mature at a smaller size than do those on the coast (Chittleborough, 1976).

Table 1) Summary statistics for lobsters tagged and released in coastal waters and at the Southern Group of the Abrolhos Islands.

		Coast		Islands	
		Control	Stunned	Control	Stunned
Sub-76 mm CL	Male	684	569	691	661
	Non-reproductive Female	867	900	886	914

	Setose Female	0	0	30	35
	Tar spot Female	0	0	147	91
	Berried Female	0	0	20	19
76+ mm CL	Male	259	274	57	59
	Non-reproductive Female	232	247	46	37
	Setose Female	0	0	26	24
	Tar spot Female	0	0	124	112
	Berried Female	0	0	30	26
	Totals	**2042**	**1990**	**2057**	**1978**

During the tagging and release operations, the numbers of limb stumps on lobsters was recorded. In the coastal area, the numbers of old leg wounds at tagging was similar ($t = -0.757$; $p > 0.05$; $df = 4042$) in the control and stunned lobsters, being 25.7 ± 1.8 and 27.8 ± 1.9 old wounds/ 100 lobsters released, respectively. This is to be expected since the lobsters from both groups should, on average, have had similar pre-tagging histories. What proportion of this damage was attributable to damage caused during previous capture events is unknown. Undoubtedly some of this damage would have been related to fishing activity during the preceding season. Damaged limbs are regenerated over successive moults, however the potential for limb regeneration over the off season period from July 1 to November 14 is unknown, because moulting activity of this size class over this period is not well understood.

At the time of capture, control lobsters bore significantly greater numbers of new wounds (14.4 ± 1.2 new leg wounds/100 lobsters) than stunned lobsters (10.7 ± 1.0 new leg wounds/100 lobsters) ($t = 2.422$; $p < 0.05$; $df = 4042$). These figures are the numbers of new wounds on lobsters not including those lost during tagging, measuring and inspection. Undoubtedly a large proportion of this new damage was due to predator damage incurred by lobsters trapped in pots on the sea floor overnight prior to retrieving the gear. However, this type of damage should have been constant over both groups, and therefore would not be expected to result in the difference

observed. The difference may be partly due to reduced on board leg loss in stunned lobsters during pot-tipping and emptying into the cacka box prior to inspection by the taggers (see below).

Lobsters tagged at the Islands came aboard with much lower numbers of old wounds than lobsters tagged inshore. At the time of capture, control and stunned lobsters showed 14.1 ± 1.3 and 14.3 ± 1.3 new leg wounds/100 lobsters, respectively. These values were not significantly different ($t = -0.088$; $p > 0.05$; $df = 4033$). The reason for the lower numbers of old wounds at the Islands is unknown. It may due to the fact that the number of boats working in this area of the Islands is typically low, thus lobsters might be have been caught and released as undersized less often than those inshore where the number of boats working is quite high. If this is true, the greater numbers of 76+ mm CL lobsters tagged inshore would result in underestimation of the true difference. Certainly anecdotal evidence suggests the densities of predatory fish species at the Islands is much higher than inshore and one might expect a greater degree of old pre-capture damage due to increased interactions with predators. However, this was clearly not the case. As with the lobsters tagged on the coast, the similar numbers of old wounds on lobsters in the two groups at the Islands indicates similar pre-tagging histories for all lobsters.

At the time of release control and stunned lobsters tagged at the Islands showed similar numbers of new leg wounds (13.4 ± 1.2 and 14.1 ± 1.4 new leg wounds/100 lobsters, respectively) ($t = -0.409$; $p > 0.05$; $df = 4033$).

During inshore tagging operations, control lobsters on average shed 25.3 ± 2.2 legs /100 lobsters handled, whereas stunned lobsters shed significantly fewer legs at the rate of 5.4 ± 0.9 legs/100 lobsters ($t = 8.288$; $p < 0.05$; $df = 4042$). This represents a 78.6% reduction in leg loss due to cold-stunning.

At the Islands, control lobsters shed 21.8 ± 1.8 legs/100 lobsters and stunned lobsters shed only 7.2 ± 0.9 legs/100 lobsters - a significant 67% reduction when compared to the controls ($t = 7.137$; $p < 0.05$; $df = 4033$). These reductions in on board leg loss resulting from cold-stunning are similar to those recorded during sea trials of cold-stunning aboard working commercial lobster boats (Davidson and Hosking, under review). In that study, very low levels of on board leg loss were observed on commercial lobster boats working in waters around the Abrolhos Islands,

whereas quite high rates of on board leg loss were observed during tagging of lobsters at the islands in the present study. This may be partly due to the greater handling of lobsters required during tagging. In addition the observations of Davidson and Hosking were made at a different time of the year and these authors showed that on board leg loss can vary greatly depending upon the time of year.

In total, 1621 tags were recaptured from the two areas. Thirty-five of these (2.2%) were illegible presumably through having been chewed by other lobsters. This type of damage was first noted by Chittleborough (1974). The percentage of illegible tags reported in the present study is very consistent with Chittleborough's findings. In contrast, Melville-Smith and Chubb (1997) found a much higher percentage of illegible tags amongst returns (23.5%). However, lobsters in that study had been at liberty for up to 12 months and this would allow more time for damage to occur. In the current study tagged lobsters were at liberty for an average of only 50 days. Melville-Smith and Chubb (1997) also found that tag mutilation was significantly greater at Island sites than on the coast. However, because the codes on the mutilated tags from the current study could not be verified, it was not possible to determine which area the tags came from for all cases and corroborate Melville-Smith and Chubb's earlier findings.

Fishermen were also asked to report the gender of recaptured lobsters. Gender was reported for 1657 recaptured lobsters. These data showed that 286 (17.3%) of recaptured lobsters apparently changed sex during their time at liberty, which gives some indication of the reliability of the data set. The reliability of lobster size (CL) data measured at recapture by fishermen was also doubtful, but some inferences regarding growth of tagged lobsters may still be drawn (see below). Fortunately the key piece of information sought in this study was that tagged lobsters were in fact recaptured. This was confirmed in all cases by recovery of the tag.

In the coastal tagging area 637 tags from control lobsters were returned giving a 31.2% recapture rate. Six hundred and forty eight tags from stunned lobsters were returned for a recapture rate of 32.4%. The percentage recaptures in the two groups were not significantly different (χ^2; $p > 0.05$). This suggests that the cold-stunning treatment applied did not adversely affect the survival of the returned lobsters.

The first thing to note about the tag returns from the Islands area is that the numbers of returned tags were much lower (about 70% lower) than for the inshore area. This is simply due to the fact that the number of boats fishing in the Islands tagging area was low and that the Islands season only runs for 3.5 months, as opposed to 7.5 months in the inshore area. When looking at the relative percentages of the control and stunned lobsters recaptured at the Islands, 210 tags (10.2%) from control lobsters were returned, whereas only 157 tags (7.9%) from stunned lobsters were returned. In contrast to the situation inshore, the percentage of stunned lobsters recaptured at the islands was significantly lower than for the controls (χ^2; $p < 0.05$). This suggests that stunning reduced the survival of returned lobsters in this area. Probably the most obvious potential explanation for the difference observed in the recapture of stunned lobsters in the two areas is predator density. The density of predators at the Islands is much greater than inshore and it is possible that stunned lobsters at the Islands suffered greater predation as a result. In fact the higher predator density at the Islands was the very reason why tagging was conducted there - to test the effect of stunning on the returned lobsters under what was thought to be the worst possible conditions. Underwater video footage confirmed that returned stunned lobsters are eaten by bronze whaler sharks (*Charcarhinus brachyurus*) and baldchin groper (C*hoerodon rubescens*), but comparable footage was not obtained for control lobsters. This does not mean control lobsters did not suffer predation, but rather that it was not observed directly. To confuse matters further, concerns were raised that the numbers of recaptures from the Islands may be too small to allow reliable conclusions to be drawn (Prof. B. Phillips, pers. com.). Because of the uncertainty surrounding the results, the FRDC Rock Lobster Post-harvest Sub-program Steering Committee requested that additional tag and recapture work be conducted.

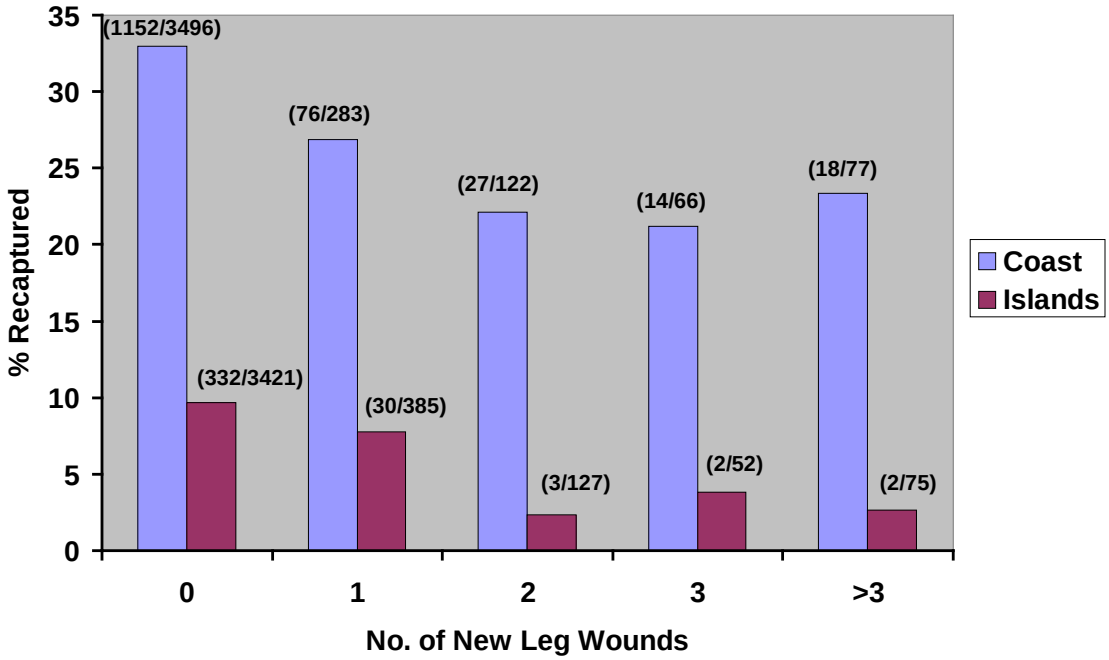

Figure 5) Percentages of lobsters with recaptured according to the number of new leg wounds at release. Data for control and stunned lobsters combined in each of the 2 tagging areas.

Figure 5 shows the percentage of lobsters recaptured against numbers of new leg wounds at release. The data show a clear trend for the percentage of lobsters recaptured to decline as the number of new leg wounds increases. What is particularly striking is that in both tagging areas even one new leg wound was enough to reduce the recapture rate by approximately 20% when compared to lobsters with no new leg wounds at the time of release. Similarly, Brown and Caputi (1986) found that in 3 out of 4 tagging trials, damage significantly reduced the recapture of tagged and released undersized western rock lobsters.

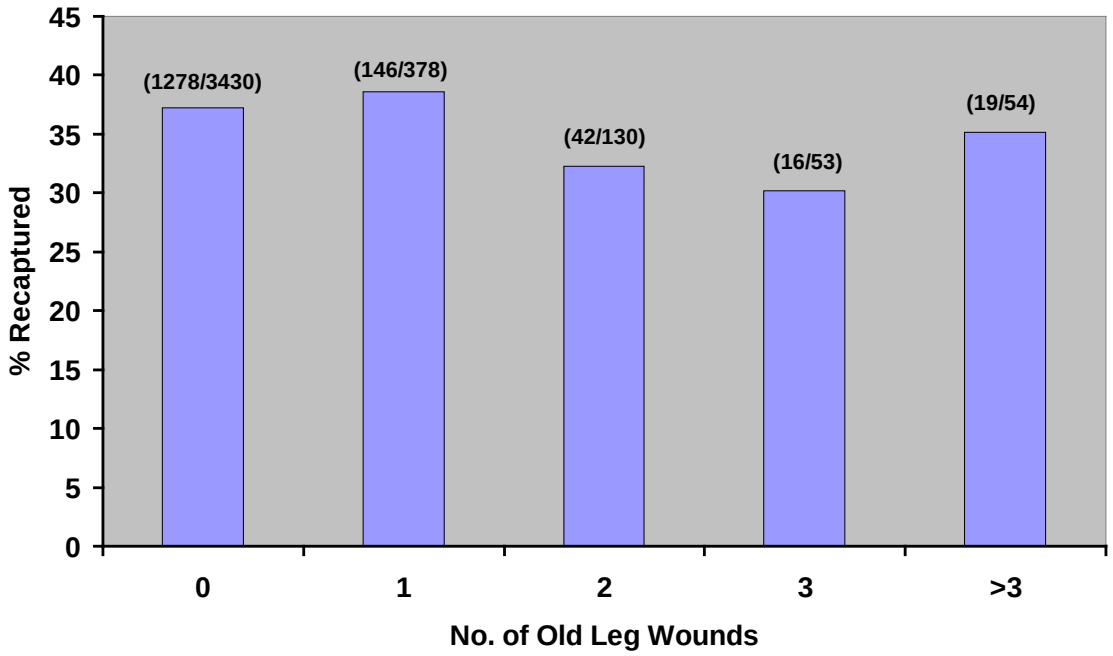

Figure 6) Percentages of lobsters recaptured in inshore waters according to the number of old leg wounds at release. The data for control and stunned lobsters have been combined.

In contrast to the effect of new wounds at release, the number of old wounds at release had no apparent effect on the probability of recapture (Figure 6). This suggests that the effect of new wounds at release on recapture was related to the presence of new wounds, rather than the absence of legs *per se*.

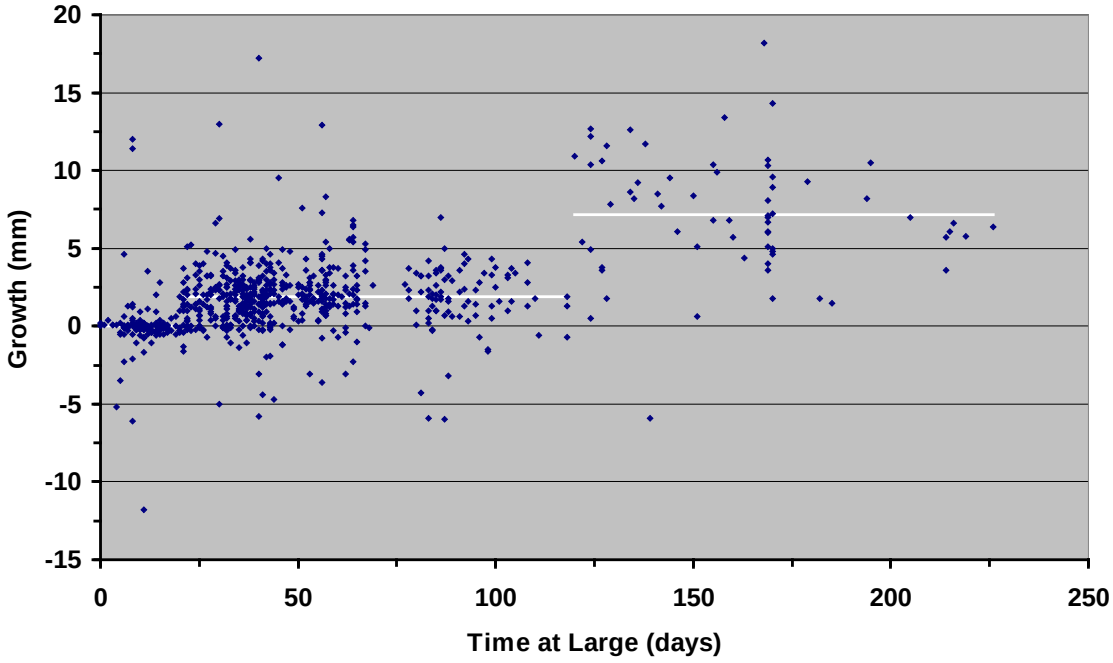

Figure 6) Growth (increase in CL) vs. time at large for lobsters tagged and released in coastal waters. The white horizontal bars show the average CL of lobsters caught during the period under the bar.

When increase in CL was plotted against time at large it was clear that there was a high number of unusual values. For example, in many cases lobsters appeared to shrink during their time at large, whereas others "grew" by large amounts. This raises questions about the quality of any data collected by fishermen in the field. However, if the errors occur randomly, that is to say are distributed randomly above and below the mean, the mean value should still be accurate albeit with increased standard error terms. Looking at Figure 6 it would appear that lobsters tagged in coastal waters showed two main periods of growth; one after about 20 days at large (presumably the "whites" migration) and a second after about 120 days at large. As a crude way of estimating moult increments, the average increases in CL were calculated between these times. Between 0-19 days at liberty, the average increase in CL was 0.01 ± 0.19 mm (n = 123), suggesting there was virtually no moult activity during this period. Between 20-118 days at liberty the average increase in CL was 1.88 ± 0.09 mm (n = 553), and between 120-226 days at liberty, this figure was 7.16 ± 0.48 mm (n = 65). These data are fairly consistent with values of moult increment found by previous workers. For example, Brown and Caputi (1983) showed that

moult increment in undersized (72-75 mm CL) lobsters with up to 6 missing legs was between 1-5 mm. Missing legs significantly reduced moult increment. The data presented in Figure 6 includes data from all lobsters (ie, damaged and intact). Using biological tags, Melville-Smith and Chubb (1997), showed that moult increment in this size range was typically 3-7 mm. The fact that the second increase in CL appeared much larger than the first is perhaps not surprising, given that the first apparent moult increment (in the period 20-118 days at liberty) actually underestimates the true value, because some non-moulting animals will be included. With a greater time at liberty, there would be fewer non-moulted animals in the sample, resulting in an apparent increase in the average growth.

Underwater video footage of returned lobsters showed that lobsters stunned for the recommended time at the appropriate temperatures recovered quickly (within 1-2 sec) upon return to the ocean and, upon reaching the sea floor, quickly sought shelter under reef outcrops. Both baldchin grouper and bronze whaler sharks were seen to predate stunned lobsters. Video footage of unstunned lobsters being eaten was not obtained. This is not to suggest that it doesn't occur, but merely indicates insufficient time was spent trying to capture such behaviours. Anecdotally many fishermen report that bronze whalers will indeed take returned lobsters that have not been stunned. According to the field staff, bronze whalers appeared reluctant to take lobsters when there was a choice between lobsters and spent bait (blue mackerel heads), but when lobsters were returned to the water without throwing spent bait overboard a shark was observed to take a lobster on one occasion.

Lobsters released in 10-12 m of water after stunning on board for excessive periods (60 secs) did not recover by the time they reached the ocean floor. One such lobster was attacked and dismembered by predatory reef fish, such as baldchin grouper.

In all, insufficient filming was undertaken to draw quantitative conclusions about the frequency of predation on stunned and control lobsters by predatory fish species. However, when applied correctly, cold-stunning appeared to have minimal impact upon the behaviour of returned lobsters.

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Benefits and Adoption

To date on board cold water stunning has only been installed on a handful of commercial lobster boats. Wide scale use of the technique has not been widely promoted because of the lack of information regarding its effects on the survival of commercially caught and returned protected lobsters, such as breeding females and undersized. The present study has not conclusively demonstrated a positive, neutral or negative impact on returned lobsters and, as a result on board cold-stunning can not be confidently endorsed and adopted. Further work has been requested to clarify the situation (see below).

Further Development

As a result of the low numbers of tags returned from lobsters tagged and released in the Abrolhos Islands (A) zone, a repeat of this work was requested by the FRDC Rock Lobster Post-harvest Sub-program Steering Committee. The additional work was to also include a cost-benefit analysis weighing up the relative mortalities of the treatments against the expected commercial and stock-related benefits of applying cold-stunning. At the time of printing this report, a proposal had been submitted to FRDC by the WA Department of Fisheries for consideration for funding in the 2005 round.

Planned Outcomes

All participants in the western rock lobster fishery, both commercial and recreational, will benefit from any individual's efforts to reduce leg loss in returned lobsters. Fishers will benefit through increased catch weights and recruitment, and improved product quality and marketing. Overall, the expected benefits of the proposed research will allow a more efficient use of the available resource, an increased financial return to fishermen and processors and an enhanced market reputation of the western rock lobster.

This study was intended to demonstrate the effect of cold water stunning on the recapture rate of returned commercially caught undersized lobsters, however the results have perhaps generated more questions than answers and further work has been suggested in order to clarify the outcomes (see Further Development).

Conclusion

Cold water stunning is an effective method for reducing leg loss during post-harvest handling of western rock lobsters. Cold-stunning can be applied at all points in the handling chain.

The present work has shown that, under the conditions of this study, cold-stunning can be applied safely on board commercial lobster boats operating in Zone B inshore waters between Geraldton and Dongara without affecting the recapture rate of returned undersized lobsters. However, in waters surrounding the Southern Group of the Abrolhos Islands, , recapture rate of stunned and returned lobsters appeared to be reduced when compared to unstunned controls. The latter result however, was deemed inconclusive due to very small numbers of recaptures of tagged lobsters.

The conflicting results from the two tagging areas has highlighted the need for further work to examine the relative recapture rates over a wider geographic range. In addition, after observing the behaviour (or lack of behaviour) shown by lobsters returned to the ocean after extended cold stun times, the effect of longer cold-stun times on recapture rate should also be investigated. This would clarify the effects of cold-stunning on returned lobsters and would allow investigators to recommend safe maximum cold stun times.

Appendix 1: Intellectual Property

None. All information generated by this project is in the public domain and has been made freely available to industry.

Appendix 2: Staff

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