

# APPENDIX 1

## Final Report

Development of bait saving strategies for the western rock lobster fishery

FRDC project Number: 2006/212

## Introduction

The Western Rocklobster (spiny), *Panulirus cygnus* George, is found off the coast of Western Australia between North West Cape (21°45'S.) and Cape Leeuwin (34°22'S.) (Jernakoff & Phillips 1988). This fishery is one of the world's largest Rocklobster fisheries with an overall value in 2002/3 of AUD\$278 million (De Lestang & Smith 2004). In March 2000, it became the first fishery in the world to be certified as ecologically sustainable by the Marine Stewardship Council. The sustainable catch is estimated at between 10,000 and 15,000 tonnes per year, whilst the actual catch has been maintained at between 8,500 and 14,400 tonnes per year since the 1980's (Melville-Smith *et al.* 2004). The 2000-2001 commercial Western Rocklobster season saw fishermen use approximately 16,000 tonnes of frozen bait to land approximately 11,000 tonnes of Western Rocklobster (Melville-Smith *et al.* 2004). At today's price for bait (i.e. \$1.35 - \$1.50 per kilogram, Neil Dorrington, commercial fisher, pers.comm.) this would equate to an annual expenditure of between \$21 and 24 million. Any reduction in the amount of bait used that does not impact on the number of lobsters landed has the potential for significant cost savings to the industry. Two ways in which such a reduction could be made are through the use of artificial baits and bait saving devices. For such methods to be accepted by the industry they must be as effective in catching lobsters as the traditional method of fishing and also be easy to deploy and result in cost savings to fishermen. Trials investigating the efficacy of commercially acceptable dry, water stable artificial baits found them to be nowhere near as effective as traditional methods (Hoxey 1996, 1999; Caputi *et al.* 1999). No comparable studies have been undertaken regarding the efficacy of bait saving devices.

In addition to attracting Western Rocklobster, bait is also likely to attract non-target species. For example, amphipods and isopods (Fig. 1) have been shown to consume baits (and lobster) in lobster traps of some American and Japanese fisheries (Bowman 1974; Sekiguchi *et al.* 1981; Sekiguchi 1982; Stepien & Brusca 1985). The consumption of the bait by a non-target species prior to lobsters being attracted is likely to reduce the catchability of that trap (see for example Sekiguchi *et al.* 1981).

Data collected during a sampling program to determine the species of sea lice present in Zone C (Winzer, unpublished thesis), in addition to those collected in a written questionnaire distributed to commercial fishermen in Zones B and C (Winzer, unpublished thesis), indicated that when lice numbers were low there was still some bait in pots after 24 hours. In contrast, when sea lice were abundant no bait remained in pots after one day. Therefore, when sea lice are abundant, it is likely that they will consume much of the bait used by lobster fishermen. Consequently, when sea lice are abundant the catchability of pots is likely to be reduced, particularly when soak times exceed 24 hours. In order to combat this loss of bait to lice, fishermen force as much bait as possible into their bait boxes, however, data from Winzer (unpublished thesis) indicated that this ploy did not result in bait remaining after 24 hours. Thus, the development of devices that exclude sea lice from entering the bait box, but still allow the bait to attract lobsters, has the potential to reduce the amount of bait used by commercial fisherman.

There is obvious value in developing bait-saving strategies to reduce the amount of bait used and limit the impact of sea lice on bait usage in order to increase the profitability of the industry. The future classification of a fishery as ecologically sustainable is likely to include further

considerations of the impact of that fishery on other organisms, which in the case of the Western Rocklobster fishery and other fisheries that use baited pots/traps, may include its impact on bait species. Bait saving devices thus also have the potential to consolidate the fishery as ecologically sustainable. However, although bait savers have the potential to reduce the amount of bait being used without impacting on catch rates, almost all commercial fishers consider that bait savers will reduce their catches and consequently are loath to use them. Furthermore, while at least two bait-saving devices are commercially available, no data are available regarding their efficacy.

The overriding objective of the current project was to test the hypothesis that pots using bait savers containing reduced quantities of bait would catch the same numbers of lobsters (both legal and undersize) as conventional pots using the typical amounts of bait employed in the fishery (and thereby provide a saving to fishers).

As noted above commercial fishers are loath to use bait savers, thus, the first specific aim of this project was to build on a short preliminary trial (WAFIC IDU Project 04: 01)

to determine the potential of bait savers as a cost saving measure. The preliminary trial (see Results) led to the development of the following hypotheses that are tested in this project:

- Bait savers will be cost effective when deployed during periods when sea lice are abundant.

- Using a bait saver in one bait box and the traditional method of bait deployment in the second box will be cost effective.
- The development of a bait saver that provides an effective plume but still protects the bait from sea lice will be the most cost effective method of deploying bait and provide substantial savings to fishermen.

## **Materials and Methods**

### *Preliminary trial*

#### *Personnel & Location*

The study was conducted over a twelve day period (8/10- 20/10 2004) during the last quarter and new moon phases of the lunar cycle, and took place in conjunction with the 2004/5 Western Rocklobster breeding stock survey in zone B of the fishery (ranging from S31°02 161 E115°18 850 to S31°03 463 E115°19 119). This trial was conducted in typical shallow, coastal nursery areas where juvenile Rocklobsters forage. A commercial Rocklobster fisherman and his boat were hired for the duration of the trial to ensure the fishing practices used were consistent with those employed in the fishery by commercial fishermen.

### *Baitsaver descriptions*

Two types of commercially available bait savers were provided for use in this study by their designers John Servass and Graheme Drew.

The first, (designed by John Servass) consists of two 95 mm diameter half cylinders (moulded plastic) placed around the bait (Fig. 2). These are held closed by a sacrificial anode thereby preventing sea lice from attacking baits during daytime hours. Once the anode dissolves, elastic bands cause the cylinders to open allowing lobsters and lice access to the bait. Two types of anode are available, the first, recommended for one day soak times, takes approximately five hours to dissolve, whilst the second, recommended for two day soak times, takes approximately ten hours to dissolve (John Servass Jr, personal communication). For each of the pots scheduled for one-day soak times, bait savers were fitted with five hour sacrificial anodes. Those scheduled for two-day soak times were fitted with ten hour sacrificial anodes.

The other commercially available device (Graheme Drew's) is a simple flip-top canister with a series of small slits (2 mm x 40mm) down the sides permitting water flow (Fig. 3).

A third bait saver (Fig. 4) was designed specifically for this study and comprised a 100 mm diameter P.V.C. pipe with the ends closed by two bored-out 100 mm P.V.C. end caps, each containing 0.05 mm mesh inserts.

### *Experimental Design*

Thirty-two regular jarrah batten pots of the form used by commercial fishermen (Bowen 1980) were deployed, 16 of which were pulled every day and 16 of which were pulled every second day. Within each of these two groups of 16 pots, four pots were deployed using the traditional fishing practice of filling each of the two bait boxes within each pot with approximately 2 kg of bait (4 kg per pot). Four were deployed with John Servass bait savers, four with Graheme Drew bait savers and four were deployed with the bait saver designed for the current study. Each of the trial pots contained a single bait saver with approximately 0.5 kg of blue mackerel as bait. For the duration of the trial, a maximum of 48 replicates for each treatment using one day soak times and 24 replicates for each of the treatments using two day soak times were possible, weather conditions permitting.

The most appropriate way to deploy the experimental pots would be truly random but a completely random deployment would be very time consuming, hard to follow and difficult for the fisherman to execute. The following design was utilized as it was quick and easy for the fisherman and included some randomness within its design. On the first day of the trial the first four pots were randomly assigned to each of the three treatments and the control. The next four pots were then assigned a treatment/control in the same order as the first four, and so on through to the full 32 pots. Each time that pots were redeployed after retrieval, the order of treatment was rotated, such that pot one (the control) was redeployed with treatment two, treatment two became three, treatment three became four and treatment four became the control. The

treatments were: Control, 1; John Servass bait saver, 2; Graheme Drew bait saver, 3; new design bait saver, 4.

All pots were deployed on a weed/rock substrate at a depth of 7-12 fathoms (13-23m), ensuring that depth and bottom conditions were standard for all pots. The distance between pots was set at least 100 metres to ensure catch rates of neighbouring pots were independent of each other (Jernakoff & Phillips 1988). Lobster pot escape gaps remained open in order to simulate a commercial fishing situation. Although different amounts of bait were used in the control group and the bait saver groups the design emulates a commercial fishing scenario where fishermen pack both bait boxes to their capacity of 2 kg each (i.e. 4 kg of bait in total), in comparison to bait savers (0.5 kg in total). Lobsters caught across the respective treatment/control groups were returned to the water after being counted, carapace lengths measured and recorded. Pots were rebaited and redeployed, with the treatments rotated after each pull as noted above.

As a consequence of bad weather over days 3-4 (11/10-12/10) of the deployment trial, pots could not be pulled, consequently on day 5 (13/10) all pots were pulled (one and two day soak time replicates) and considered a three day soak time. A risk analysis conducted prior to the commencement of the deployment trial had identified inclement weather as a threat. Therefore the experiment was designed in such a way that it was sufficiently robust to overcome such an event occurring once or twice.

## *Statistical Analyses*

Rather than performing a harsh transformation on the raw data, a randomisation test was used (Edgington 1995). Such a test is ideally suited to the type of data collected during the preliminary study, as it doesn't rely on assumptions of normality or equal variances. The randomisation method is ideal for testing sharp null hypotheses, that is, null hypotheses under which all potential outcomes are known exactly. The null hypothesis, which is assumed to be true for the purpose of the trial, states that the two sets of data are drawn from the same distribution (i.e. the treatment has no effect on the value of catch per pot recorded for each pot lift). Comparisons between a control and treatment group of the same soak time are ideally suited to a two-sample situation when attempting to compare the means of two sets of values by determining a t-statistic.

Comparison between a control and a specific treatment group and soak time involves pooling all values, and randomly selecting, with replacement, another complete data set from these original two treatment groups. The total sample size is then halved and assigned to the set number 1, our control group and the other remaining half of the data set is assigned to set number 2, our treatment group. A measure of the difference between the means is then calculated with equal sample sizes and unequal variances using the standard formula (but recognising that this is not the t-statistic that would be used with a standard table of t-values). This value is calculated by subtracting the mean of the treatment group from the mean of the control group, then dividing by the estimate of the standard deviation of the difference between the means. This statistic was

calculated 20,000 times producing a very large number of random observations of the values of the t-statistic that one would be likely to encounter if the null hypothesis was true.

The final step in the calculation was to calculate the test statistic from the original pooled set of data (comprised of the control and a treatment group across a respective soak time). A count was then performed of the number of times within 20,000 observations from the null hypothesis that a value of the test statistic is obtained that is equal to or exceeds the value calculated from the recorded data. This count was then divided by 20,000 to provide an estimate of the probability that a test statistic value as large as that which was observed in the deployment trial could have occurred by chance if the null hypothesis was true.

This is a single-tail test as all that is being tested is whether the total catch of lobsters (size and undersized) obtained with the treated pots is significantly less than the catch obtained by the control pots using the same soak time. It is assumed that the test statistic calculated is an appropriate measure of the difference between the mean catch per pot lift recorded across each treatment group and soak time. An additional assumption of this study is that there are sufficient observations in the combined data set and that a random sample with replacement is representative of the distribution of values that would be recorded if the experiment had been repeated (at the same time as the original trial, at the same location, with the same density of lobsters and under the same environmental conditions).

Insufficient numbers of replicates across all treatment groups prevented analyses of the effect of three day soak times on catch rates.

### *Cost benefit analyses*

In order to provide an estimate of the costs and/or benefits associated with using bait savers to fishermen a cost benefit analysis was performed. It is important to note that, as the cost benefit analysis had to rely on the raw data obtained from this study that was conducted over a twelve-day period in inshore grounds of Zone B, the following major assumptions had to be made:

- 1) That this twelve day fishing period is representative of an entire season.
- 2) That inshore and offshore catch rates are the same.
- 3) That catch rates are the same in all zones.

The model also assumes that:-

- 4) Bait costs are \$1.35 per kg.
- 5) Fishermen receive \$19.00 per kg of lobster or approximately \$9.00 per animal.
- 6) The fisherman is licensed for 100 pots.

*Number of one-, two- and three-day soak times.* Commercial fishermen provided an estimate of the number of one-, two- and three-day soak times that they employed throughout an entire season. The estimates provided by fishermen operating predominantly in inshore grounds indicated that they had fewer two- and three-day soak times than the fishermen who operated predominantly in offshore grounds. Therefore, the following cost benefit analyses were performed independently for these two groups and used 213 one-, 12 two- and four three-day soak times for inshore fishermen and 175 one-, 25 two- and eight three-day soak times for offshore fishermen.

*Return per pot per lift.* The return per pot, i.e. the value of the catch minus the cost of bait, was determined for all treatment groups. These values were calculated for the mean, and the upper and lower bounds (95% C.I.). These values were used to derive the annual gross return projections below.

*Annual gross return.* Based on the estimated number of one-, two- and three-day soak times provided by inshore and offshore fishermen and the return per pot per lift calculated above, the hypothetical annual gross return for a fisherman who has 100 pots was calculated. This estimate included the costs of buying the relevant bait savers where appropriate.

*Combining methods.* A fourth analysis was performed that provided an estimate of the costs/benefits associated with filling one bait box with bait in the traditional way and using a bait saver in the other bait box. This analysis assumes that the combination will be as effective as the traditional method for one-day soak times and equally as effective as bait savers over two- and three-day soak times. During the preliminary study the pots using the traditional deployment method caught more lobster than those using bait savers for the one-day soak time. However, no differences were detectable between the methods of deployment for the two-day soak time, whilst for three-day soak times the new design of bait saver seemingly provided better catches. This model further assumes that pots using the traditional deployment method have bait remaining in the pot after 24 hours and are therefore still fishing effectively; this is apparently the case when sea lice are in low abundance. The use of a combined method of bait deployment should therefore have no adverse effect on catch rate. However, in times when lice are very

abundant the use of a bait saver may in fact increase the catchability of pots as a bait plume from the bait saver will still be attracting lobsters to the pot (see Discussion).

### Season long trial 2005/6

As the preliminary trial suggested that bait savers could provide savings to the industry a season long trial that incorporated zones A, B and C was planned.

### *Bait saver modifications (previously referred to as New design bait saver)*

Seasonal sampling of sea lice populations using sea lice traps over the past three commercial seasons has provided insight into temporal and spatial variations in size frequencies of the dominant species of sea lice, *Cirolana hesperia* found throughout the fishing zones off the West Australian coastline. In light of these findings, the bait saver designed for the season long trial was modified (i.e. based on the length frequency data for lice collected during the study on the distribution and prevalence of sea lice in Zone C of the lobster fishery, see Winzer, unpublished thesis) and the fine 0.05 mm mesh was replaced with a coarser, heavy-duty NITEX™ mesh of 0.5 mm aperture. This particular sized mesh has been especially successful with fishers primarily located in deep waters (i.e. in excess of 25 fathoms) as the median size of lice at this depth is approximately 4.5mm in width. Therefore, this mesh size prevents the majority of the deep water cirolanid population from entering the bait saver while still being sufficiently coarse so as to attract lobster. It is also envisaged that this particular sized mesh will also prove beneficial for fishers occupying shallow, inshore zones. It is anticipated this bait saver when

deployed in combination with a traditionally packed bait box over a one and two day soak time will provide bait protection from buffeting and/or lice predation while permitting a strong odour plume and thus attracting lobster.

### *Personnel & Location*

Respondents to the survey entitled “Survey on the effect of sea lice on lobster baits” that were interested in providing further assistance in the present study were contacted. One commercial fisherman from each of zones A and B, and three from Zone C were chosen from this list of survey respondents to participate in the season long trial. None of the participants in this trial were under any obligation to use the bait savers for any designated period of time. As a result of the diminishing catch rates and consequent below average annual landings incurred by commercial fishers over the past two seasons, competition within the fishery has reached new heights. Understandably, if a fisher using the bait saver was of the opinion that his landings were suffering as a result, he was under no obligation to proceed further. Consequently, the design and to some extent the success of the current trial was somewhat reliant upon its participants having an above average season. A successful season would effectively provide the grounds for a robust feasibility study comparing catch rates of lobster using the bait saver and those derived using traditional means across the respective fishing zones. Additionally, ongoing use of the bait saver over the duration of an entire season in which catch rates were above average would allow fishers to develop opinions on the perceived strengths and weaknesses of the bait saver. This informed point of view would provide further insight into potential enhancements in the design of a bait saver in general, and also whether modifications to the design may be required for

different zones and/or times of year (e.g. if sea lice size varies across zones or through time, aperture size may be changed).

In an effort to encourage ongoing participation, the design of the trial was made to be as flexible as possible while ensuring meaningful conclusions could still be drawn. Some commercial fishers participating in the trial deployed 10 bait savers on a daily basis while others deployed them twice a week. As a consequence of well below average catch rates for the 2005/6 commercial season, participants in zones A and B withdrew from the trial whereas fishermen from Zone C felt that whilst bait savers alone could not be justified under the current catch rates they were happy to complete the combination trial. Indeed, their initial thoughts were that bait savers were effective when used in conjunction with the remaining bait box being filled in the traditional manner. As a result, it was only possible to analyse the data provided by Zone C fishermen and determine whether pots deployed with two full bait boxes caught more lobster than those using a combination of one bait box containing 2kg of fish and the other containing 0.5kg of fish in a bait saver.

#### *2005/6 Input controls on Western Rock Lobster fishery*

One particular input control introduced in zone C at the commencement of the 2005/6 season by the Department of Fisheries Western Australia was a mandatory three day closure in tandem with the full moon from February through to June. Most participants in the bait saver trial used this period to dry out pots (i.e. out of the water) as it is the belief among commercial fishers that this extended period of time in the water results in pots being damaged by scavenging polychaete

worms. However, on the odd occasion that a fisher did leave his pots in the water, the resultant numbers of lobster trapped were classified as 72 hour or three day soaks. As was the case with the previous 12 day trial (Winzer, unpublished data), insufficient numbers of three day soak replicates across the entire fishing season prevented any meaningful statistical analyses. Nevertheless, the mean numbers of lobster landed and the associated standard error have been tabulated to allow some form of comparison to be made.

### *Experimental design*

Although the most appropriate way to deploy the experimental pots would be truly random, a completely random deployment was seen as being very time consuming, hard to follow and difficult for the fisherman to execute. Thus, the following design was utilized as it was quick and easy for the fisherman and included some randomness within its design. On any one day, each fisher deployed a total of ten pots containing one bait saver in one bait box (0.5 kg) and 2 kg of blue mackerel in the remaining bait box. It was at the fisher's discretion as to which bottom type and depth these ten pots were deployed. The main constraint on the fisher was that all pots were deployed at similar depths and bottom type using the same fish bait. The control pots were deployed in the traditional manner with both bait boxes packed with blue mackerel (2 kg + 2 kg) and deployed at similar depths and bottom types to treatment group pots containing bait savers. It was at the fisher's discretion as to whether these pots were deployed consecutively or in a random manner.

The distance between pots was set at least 100 metres to ensure catch rates of neighbouring pots were independent of each other (Jernakoff & Phillips 1988). Lobster pot escape gaps remained open in order to simulate a commercial fishing situation.

### *Statistical Analyses*

#### *Randomisation test*

A randomisation test was performed based on the procedure described for the preliminary trial. Two tests were performed for the season long trial data, the first was purely intended to identify significant differences between the mean numbers of lobster landed throughout the entire 2005/6 and 2006/7 seasons using the two methods of bait deployment across the two soak times. The second randomisation test focused on identifying any significant differences between the mean numbers of lobster landed within individual months of the 2005/6 and 2006/7 seasons using the two methods of bait deployment across the two soak times. In contrast to the short preliminary trial the 2005/6 and 2006/7 trials only considered the numbers of legally sized lobsters.

#### *Poisson, Quasi-Poisson & Negative Binomial Generalised Linear Model Analyses*

A GLM analyses of data collected throughout the 2005/6 and 2006/7 season long trial was also conducted in order to validate the conclusions drawn from the randomisation tests. Goodness of

fit tests were performed on three distributions in order to determine which model provided the best fit for the season long data set (i.e. Poisson versus Quasi-Poisson versus Negative binomial).

A goodness of fit test also serves as an over-dispersion test which effectively tests the equality of the mean and the variance imposed by the Poisson distribution against the alternative that the variance exceeds the mean. For the negative binomial distribution, the variance = mean + k mean<sup>2</sup> (when  $k \geq 0$  the negative binomial distribution provides the best fit, whereas the Poisson distribution provides the best fit when  $k$  is equal to or approaching zero).

Deviance and Pearson Chi-Square divided by the degrees of freedom are used to detect over-dispersion or under-dispersion in Poisson, Quasi-Poisson and Negative binomial regression. Values greater than one indicate over-dispersion, that is, the true variance is bigger than the mean, values smaller than one indicate under-dispersion, the true variance is smaller than the mean. Evidence of under-dispersion or over-dispersion indicates inadequate fit of the respective model. This 'goodness of fit' test involves subtracting twice the log-likelihood value (approx. equal to the residual-null deviance/residual deviance) derived from the respective statistical models. A probability value (z-value) is then derived (i.e.  $H_0$  = quasi-poisson is a better fit than poisson). The asymptotic distribution of the LRS (likelihood ratio statistic) has probability mass of one half at zero and one half – Chi-sq distribution with 1 degree of freedom (i.e. df) (see A. C. Cameron, P.K. Trivedi, Regression Analysis of Count Data, Cambridge University Press, 1998). This resulting value is Chi squared distributed with one degree of freedom ( $\chi_n$ ) and if one particular model does provide a better fit for the data set, a value of  $P \leq 0.05$  will imply this.

After this particular test was performed, it was decided against incorporating the poisson distribution as a result of data fitted using this model being considerable over-dispersed.

A goodness of fit test for the negative binomial model was then performed using the AIC which is essentially

$$AIC = -2 * \log\text{-likelihood} + k * n_{\text{par}}$$

where  $n_{\text{par}}$  = number of parameters in fitted model

$$k = \log(n)$$

where  $n$  = number of observations

The next step was to derive a likelihood ratio statistic (LRS) and use the likelihood ratio test described above to either accept or reject the null hypothesis ( $H_0$ ). Unfortunately as a result of the quasi-poisson distribution not having an associated log-likelihood, it was not possible to derive a LRS based on all three distributions.

$$LRS = -2(LL(\text{poisson}) - LL(\text{negative binomial})).$$

$H_0$  is rejected if  $LRS > \chi^2_{(1-2\alpha, 1 \text{ df})}$ .

After the ‘goodness of fit test’ was performed as a result of similar conclusions being drawn, it was decided to incorporate both the results of quasi-poisson and negative binomial models into the GLM analyses. These two tests allowed the two methods of bait deployment to be compared

for each month of the commercial season in addition to comparisons based on the entire season which the randomisation procedure allows.

Visual interpretation of mean monthly catches ( $\pm$  S.E.) (Figures 7 & 8) in conjunction with the results of both General Linear Models based on the Quasi-Poisson and Negative Binomial distributions suggest the traditional method of bait deployment lands significantly more lobster in the first two months of the season but is no more efficient than using a combined method of bait deployment in the remaining months. Thus, a calculation of potential cost savings with respect to bait expenditure for an individual fisherman using both traditional and combined methods of bait deployment at designated times of the season (*see above*) has been conducted.

This calculation assumes:

That bait costs have risen to \$1.50 per kg (Inc. G.S.T.).

*Number of one-, two- day soak times.* Commercial fishermen provided an estimate of the number of one-, two- and three-day soak times that they employed throughout an entire season. The estimates provided by fishermen operating predominantly in inshore grounds indicated that they had fewer two-day soak times than the fishermen who operated predominantly in offshore grounds. Therefore, the following cost benefit analyses were performed independently for these two groups and used 175 one-, 18 two-day and 5 three day soak times for inshore fishermen and 161 one-, 22 two-day and 7 three day soak times for offshore fishermen. These estimates have

changed as a result of the input controls placed on zone C of the fishery (*see Season long trial – 2005/6 input controls on Western Rock Lobster fishery*).

### Season long trial 2006/7

For the 2006/7 season additional fishermen agreed to trial the baitsavers across all three zones of the fishery, giving a total of six fishermen (two in each zone). With the exception of a slight redesign of the baitsaver, whereby slits were cut into the sides of the baitsaver to increase attractant odour plumes whilst excluding lice, and the exclusion of undersize lobster from the counts the methodology and analyses were the same as for the 2005/6 season long trial.

## **Results**

### Preliminary trials

#### *Number of Lobster per pot*

Pots that employed the traditional method of bait deployment caught a mean of 5.11 ( $\pm 0.76$ ) lobster when deployed for one day, and those that used bait saving devices caught between 2.55 ( $\pm 0.42$ ) and 3.91 ( $\pm 0.49$ ) (Table 1, Fig. 5). The randomisation tests indicated that the number of lobsters landed in pots that used the traditional deployment method was significantly different ( $P \leq 0.02$ ) from the numbers caught in those using bait savers (Table 2). Whilst there was only

slight overlap in the 95% confidence intervals of the number of lobsters landed in pots that used the traditional deployment method and those caught using the Servass bait saver, there was no overlap between the number of lobsters landed in pots that used the traditional deployment method and the other bait savers (Fig. 5).

Pots that employed the traditional method of bait deployment caught a mean of 3.50 ( $\pm$  1.06) lobsters when deployed for two days, whereas those that used bait saving devices caught between 2.20 ( $\pm$  0.66) and 2.85 ( $\pm$  0.77) (Table 1, Fig. 5). In contrast to the one day soak time, no significant differences ( $P \geq 0.15$ ) were detected between the number of lobsters landed using the traditional deployment method and the bait savers (Table 2). There was a large overlap of the 95% confidence intervals of the number of lobsters landed in pots using the traditional methods of bait deployed and those of all the groups using bait savers.

Pots that were deployed for three days caught between 2.38 ( $\pm$  0.63) (Drew bait saver) and 3.12 ( $\pm$  0.95) (bait saver designed for this study) lobsters (Table 1, Fig. 5). The small number of replicates for the three-day soak time precluded statistical analysis.

### *Cost-Benefit Analyses*

The mean maximum gross return per pot per lift of \$40.59 was obtained when bait was deployed using the traditional method over a one-day soak time, this translates to a mean annual gross return of \$792 855 and \$904 527 for fishermen operating predominantly in offshore and inshore waters, respectively (Tables 3, 4 & 5). The large overlap in the upper and lower bounds of mean return per pot per lift across all treatment groups using a two-day soak time reflects the fact that

no significant differences could be detected in the number of lobster caught using the different methods of bait deployment.

The estimate of mean return for fishermen predominantly fishing offshore grounds was far higher when using traditional methods for the whole season than when using bait savers for the whole season (Table 4). The estimate of mean return for fishermen using a combination of methods approached that for fishermen using traditional methods. The large range in the upper and lower bound estimates reflects the large variation recorded in the number of lobster landed per pot throughout the duration of the trial. As previously noted, the gross return per pot (Table 3) used to derive the annual gross return projections listed above, is based on catch rates obtained from the current trial. Despite this trial being conducted in shallow, inshore grounds the analysis still serves as a comparative tool between the respective treatment groups.

As was the case for fishermen predominantly fishing offshore grounds, the estimate of mean return for fishermen predominantly fishing inshore grounds was far higher when using traditional methods for the whole season than when using bait savers for the whole season (Table 5). The estimate of mean return for these fishermen using a combination of methods likewise approached that for fishermen using traditional methods. Taking into account the various assumptions that these analyses makes, it would seem apparent that the use of any of the currently available bait savers alone would not result in significant savings to the industry.

An increase in gross return of approximately \$45, 000 for both inshore and offshore based fishermen may be achieved by using the new design bait saver in one bait box and bait deployed traditionally in the second bait box (Table 6).

Further enhancements were made to the bait saver for the 2005/6 commercial season to cater for temporal and/or spatial variations in lice abundance. In an effort to increase the viability of the bait saver to commercial fishers, it was decided to provide two readily interchangeable mesh sizes. This enabled commercial fishers to easily change the mesh size on the end caps of the bait saver in an effort to maximise the resultant odour plume in accordance with soak time and depth of water fished.

#### Season long trial 2005/6

As a consequence of each of the fitted models reaching similar conclusions while both satisfying the majority of the underlying assumptions associated with each distribution, it was decided to report the findings of both GLM's. The quasi-poisson model, despite being over dispersed (i.e. the empirical variance in the data exceeds the nominal variance) has very similar residual and null deviances to those of the negative binomial model. The negative binomial model while relying on a less than ideal shape parameter of the gamma to deal with over-dispersion is possibly seen as being a better fit to the data set as the standard deviation of the response or dependant variable is closely proportional to the mean (Table 11).

Satisfying this relationship between the mean and standard deviation is a major assumption associated with the negative binomial distribution.

### *Catch rate over entire season*

With respect to data pooled across the entire season, the randomisation, quasi-poisson and negative binomial tests all found significantly greater mean numbers ( $P > 0.05$ ) of lobster were landed in pots using traditional methods ( $4.04 \pm 0.12$ ) in comparison to the bait saver ( $3.38 \pm 0.12$ ) over a one day soak (Table 7). In contrast, there was no significant difference in the mean numbers of lobster landed per pot between the two treatment groups using a two day soak time while minimal overlap was found between the two treatment groups with respect to a three day soak time (Figure 6). Insufficient numbers of experimental replicates for three day soak times prevented any statistical analyses from occurring.

### *Catch rates by month*

Irrespective of soak time or method of analysis, the first month of the commercial season resulted in significantly greater mean numbers ( $P > 0.05$ ) of trapped lobster per pot using traditional methods of bait deployment in comparison to the bait saver (Table 9). However, similar mean numbers of lobster were trapped per pot for the remainder of the commercial season using both traditional methods of bait deployment and the bait saver.

According to GLM based on a quasi-poisson model, the first month of the 2005/6 commercial season was the only month in which one day soak times using traditional methods of bait deployment resulted in significantly greater mean numbers of lobster per pot than those deployed

using the bait saver (Table 9). A dispersion parameter of 3.06 associated with this quasi-poisson model indicates the data is over-dispersed.

Analysis of data using a GLM fitted with a negative binomial model found one day soak times resulted in significantly higher mean numbers of lobster per pot using traditional methods of bait deployment than those using the bait saver in months one, two and five of the 2005/6 commercial season (Table 8). Whereas with two day soak times, month one of the season was the only month in which a significant difference between the two treatment groups was found.

As previously noted, there were insufficient replicates to test for differences in mean numbers of lobster landed between the two methods of deployment over a three day soak time. However, the small number of three day soaks which were recorded over the 2005/6 commercial season ( $n = 6$ ) suggested that the bait saver caught almost one and half more lobsters per pot than those using traditional methods of bait deployment. Furthermore, a smaller standard error for the bait saver replicates in comparison to traditional methods of bait deployment replicates is indicative of a fishing method which showed little variation in mean numbers of lobster per pot (Table 8).

### *Cost savings*

Cost savings to fishermen based in inshore waters resulted in 151 days in which combined methods of bait deployment resulted in an estimated 22, 650 kilogram reduction in bait usage per fisher from month three until the end of the commercial season. This equates to an annual cost saving of \$33, 975 per fisher.

Cost savings to fishermen based in offshore waters resulted in 158 days in which combined methods of bait deployment resulted in an estimated 23, 700 kilogram reduction in bait usage per fisher from month three until the end of the commercial season. This equates to an annual cost saving of \$35, 550 per fisher.

### Season long trial 2006/7

Our initial preliminary analyses of the catches for the 2006/7 season (Tables 12 & 13; Figures 9-11) indicate that there are no differences between pots deployed using the traditional method of bait deployment and those using the combined method. Thus, the use of the combined method should provide significant savings to the industry.

## **Discussion**

### *Preliminary trial*

The preliminary trial conducted in conjunction with the 2004/5 breeding stock survey clearly demonstrate that for one day soak times, pots that deployed bait in the traditional manner caught significantly more lobster than those that used bait savers. This finding supports the suspicions of commercial fishermen, i.e. that bait savers reduce catches when soak times are for one day only. The consensus among fishermen is that bait savers reduce the intensity of odour plume

released from the pots, thereby reducing the area over which they are likely to attract lobsters. In contrast to one day soak times, no significant difference could be detected between the number of lobster caught in pots using the traditional method of bait deployment and those using any of the three bait savers when deployed for two days. Although catches over a three day soak time could not be tested for significance, the data suggest that bait savers are at least as, if not more, efficient at catching lobster as the traditional method of bait deployment.

Using catch data generated during the preliminary study it is clear that, whilst bait savers reduce the amount of bait used, and thus provide fishermen with the opportunity to reduce overheads, the savings generated if they were used over the entire season would not be enough to compensate for losses associated with reductions in the number of lobster landed. The use of the traditional method of bait deployment for one day soak times and bait savers for two and three day soak times appears to be cost neutral, whilst annual cost savings of *ca* \$45 000 per fisherman may be possible if pots were deployed using the traditional method of bait deployment in one bait box and a bait saver in the other (i.e. combined method of deployment).

In summary, the following conclusions (1 - 3) were drawn and hypotheses (4 - 6) developed from the preliminary investigation into the use of bait savers in the lobster industry:

- 1) If the conditions experienced during this preliminary study, i.e. the absence of sea lice and strong currents, persisted for an entire season, then the sole use of any of the bait savers currently available would not be cost effective if they were used over the entire season.

- 2) If the conditions experienced during this study persisted for an entire season, then the use of any of the currently available bait savers would likely be cost neutral if they were used solely for two and three day soak times and bait was deployed in the traditional way for one day soak times.
- 3) Current bait saver designs require modification if they are to compete with traditional deployment methods over a one day soak time.
- 4) Bait savers will be cost effective when deployed during periods when sea lice are abundant and during periods of strong currents.
- 5) Using a bait saver in one bait box and the traditional method of bait deployment in the second box will be cost effective.
- 6) The development of a bait saver that provides an effective plume but still protects the bait from sea lice will be the most cost effective method of deploying bait and provide substantial savings to fishermen.

#### Season-long trial 2005/6

As was the case with the preliminary trial, it was unfortunate from both a commercial fishers and researcher's perspective that the 2005/6 commercial season resulted in below average landings across all zones of the fishery. As a consequence, participants in the season long bait saver trial were understandably hesitant to test a product that could potentially further reduce their landings. In addition to this, the low numbers of sea lice encountered in the shallow, inshore waters across

all zones of the fishery didn't provide any further encouragement for participants to continue in the trial.

As a result of the randomisation test performed in both the preliminary and season-long trial not relying on any assumptions being met in order to fit a particular distribution, it is recognised as being very robust and allows definitive conclusions to be drawn with respect to soak time and fishing method. Therefore, it can be said with conviction that where one day soak times were employed over the 2005/6 commercial season, traditional methods of bait deployment resulted in significantly greater mean numbers of lobster landed per pot than those deployed using combined methods of bait deployment (i.e. bait savers). In contrast, where two day soak times were concerned, no significant difference ( $P < 0.10$ ) in mean numbers of lobster landed per pot was identified between traditional methods of bait deployment and those using combined methods of bait deployment. These findings are in agreement with those of the preliminary trial in which similar conditions prevailed throughout the majority of the twelve days (i.e. low numbers of both lobster and lice, and small swells).

Further analyses of the data obtained from the 2005/6 season long trial allowed monthly comparisons in catch rates to be made between the two methods of bait deployment across both one and two day soak times. The randomisation test and GLM based on the quasi-poisson distribution both concluded that when one day soak times were employed, the first two months of the 2005/6 commercial season resulted in significantly greater numbers of lobster ( $P < 0.02$ ) in pots using traditional methods of bait deployment in comparison to those deployed using combined methods (i.e. a bait saver) (Table 9). The GLM based on the negative binomial

distribution found months one, two and five of the 2005/6 season favoured the traditional method of deployment when using a one day soak. Where two day soak times were concerned all statistical tests (i.e. both fitted GLM models and the randomisation test) reached the same conclusions that mean numbers of lobster landed per pot differed with the method of bait deployment in the first month of the 2005/6 commercial season only. Thus, the use of traditional methods of bait deployment in the first two months of the season in conjunction with the combined method of bait deployment from January until the end of the commercial season resulted in annual cost savings of \$33,000 and \$36,000 for offshore and inshore based fishers respectively. It is hypothesised that employing a similar bait saving strategy across all zones in the 2006/7 commercial season will result in similar annual cost savings to the fishery. This hypothesis will be tested across all fishing zones in the 2006/7 commercial season long trial sponsored by the Commonwealth fisheries department.

It is also hypothesised that fishers based predominantly offshore have decidedly less competition from other fishers than those based inshore. Lobster inhabiting deeper, offshore grounds are seen as being more sparsely distributed and consequently more difficult to catch and as a result when an 'informed' fisher places pots in an area in which lobster are prevalent, they will catch lobster regardless of deployment method. This theory has been accepted by numerous professional fishers (Peter Vinci pers. comm.) and fisheries scientists (Professor Norm Hall pers. comm.) who also consider the converse to be true. Both fishers and fisheries scientists believe the traditional method of bait deployment is warranted in the first few months of the season (i.e. 'the whites phase') as a consequence of lobster pots having to compete with other pots within a small area for the comparatively dense aggregations of lobster found to inhabit the

predominantly shallow, inshore areas of the fishery. This 'competition theory' for dense aggregations of lobster is supported further in figures 7 & 8 of the season-long trial section of the results which indicates that regardless of soak time or deployment method, the first two months of the 2005/6 commercial season resulted in the greatest number of lobster being landed per pot than any other. Traditionally, this is not uncommon as it is at this stage of the season that juvenile lobster (known as 'whites' because of their pale coloured exoskeleton), migrate to deeper breeding grounds to moult and reproduce. As a result of this migration taking place, lobsters are particularly vulnerable to fishing. Seemingly at this stage of the season in which predominantly 24 hour soaks take place, the use of a bait saver of any description is not warranted. It is hypothesised that throughout 'the whites phase' of the season, irrespective of soak time or fishing zone, traditional methods of bait deployment will result in significantly greater numbers of lobster per pot than those deployed using combined methods (i.e. a bait saver). It is also hypothesised that irrespective of soak time or fishing zone, combined methods of bait deployment will be equally effective as traditional methods for the remaining six months of the season (i.e. predominantly 'the reds phase'). Interestingly this apparent disparity in catches during the early and later parts of the season was not apparent in the 2006/7 season. We are currently investigating probable reasons for this.

As was the case with the preliminary trial, fishers predominantly deploying pots throughout the duration of the 2005/6 season long trial in shallow, inshore grounds found that bait generally remained in pots using the traditional method of deployment after one day, the soak time that had the highest catch rates for these pots. While after two and three days little if any bait remained in pots using the traditional method of bait deployment and their catch rates were not detectably

different to those using bait savers. The season long trial also demonstrated that when sea lice were abundant little if any bait remained in pots after one day. As a result the catch rates after a one day soak time using the traditional method of bait deployment in the presence of high sea lice numbers resembled those recorded for two and three day soak times. Secondly, a lack of inclement weather (i.e. small swells and seas) experienced in the initial few months of the season long trial possibly contributed towards the significantly lower average landings when pots were deployed using the bait saver. Generally speaking, a lack of inclement weather equates to minimal bait agitation and therefore it is likely that the bait inside the bait savers would produce a smaller plume, and consequently be less efficient at attracting lobster. However, when swells and currents are large and strong, bait savers are likely to provide some protection from buffeting, thereby maintaining the integrity of the fish bait, effectively extending the leach time and subsequent catchability of the pot beyond those deployed using traditional means.

While being ideally suited for conditions such as inclement weather, it is felt that providing commercial fishers with custom sized fine and course sized mesh for the bait saver will only increase it's capacity to cater for varying soak times in addition to an estimated 3000% variation (temporal and/or spatial) in lice abundance encountered across the various zones of the lobster fishery. This estimate of variability in the numbers of sea lice found in lobster pots is based on three seasons of sampling with the assistance of commercial fishers using a custom designed lice trap. This considerable variation in the abundance of sea lice found in lobster pots is possibly related to temporal fluctuations in the extent to which the warm water Leeuwin current and it's corresponding vectors (i.e. El nino effect, Southern Oscillation effect) influence water temperatures and nutrient flow along the West Australian coastline (Winzer, unpublished thesis).

The extent of this variability in sea lice abundance not only equates to shifts in the extent to which fish baits are susceptible to lice predation within a particular fishing zone but also between the respective zones of the rock lobster fishery.

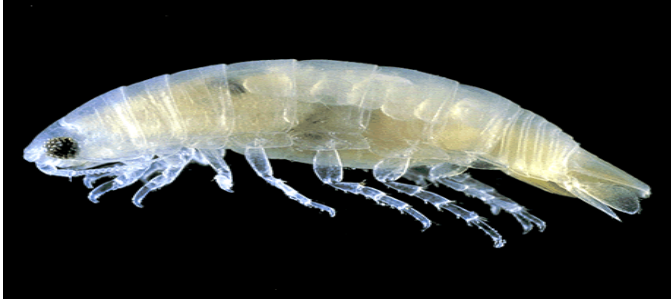
It is envisaged that recent input controls placed on the fishery aimed at ensuring long-term sustainability of the fishery, including six day fishing weeks in both zones A & B and three day moon closures in zone C provides further encouragement to fishers to seek out alternative methods of bait deployment aimed at increasing bait longevity. In addition to this, the reduction in bait usage as a result of incorporating bait savers into commercial fishing practices, while having potential cost-saving attributes also ensures fish bait species are used by the fishery in a more responsible, sustainable manner. Consequently, both the Marine Stewardships Council and Environment Australia's certification of the Western Rock Lobster fishery as ecologically sustainable is further satisfied.

Preliminary analyses of the 2006/7 season provide support for the notion that the use of baitsavers will provide significant savings to fishers. Furthermore, even though the current season was one of the worst recorded most of the participants believed that the baitsavers would provide cost savings at certain times of the year and when fished under certain conditions, whilst others believed the savings would be season round. Indeed, one of the fishers (Peter Vinci in Zone C) was so impressed with the baitsavers he would have placed them in all of his pots.

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**Figure 1.** *Cirolana hesperia*, the most common species of sea lice caught in Zone C of the Western Rock Lobster fishery (size range 2.5 mm to 12.5 mm).



**Figure 2.** John Servass' bait saver



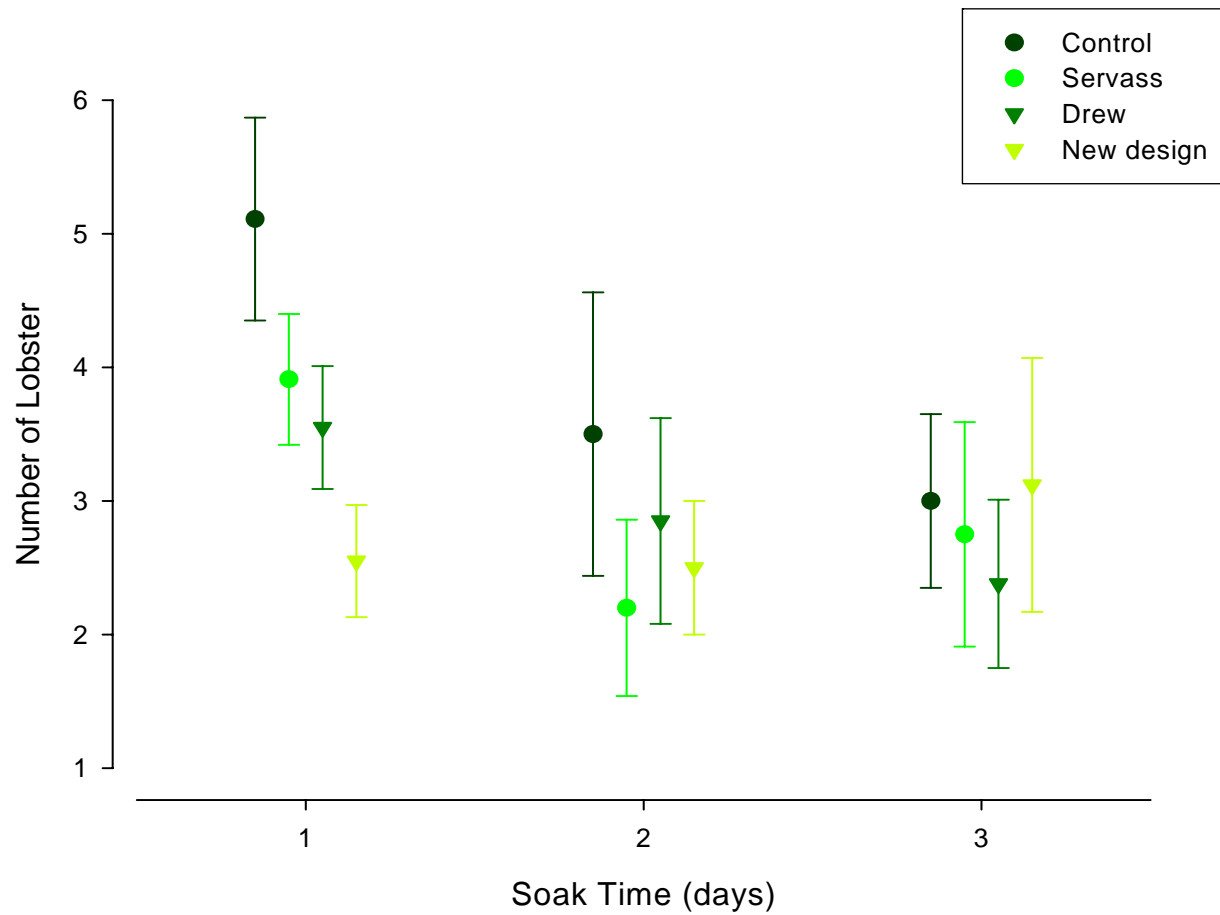
**Figure 3.** Graheme Drew's bait saver



**Figure 4.** New design (ND) bait saver with mesh sizes of 0.5 mm (left) and 0.05mm (right).

**Table 1.** Mean ( $\pm$  S.E.) and 95% confidence intervals, i.e. that the mean value has a 95% chance of falling between the upper and lower bound, the of total lobster landed using the traditional method of bait deployment, and bait deployed in the 3 types of bait saver for one, two and three day soak times.

Treatment group	Soak time	Mean ( $\pm$ S.E.)	95% Confidence Interval	
			Lower bound	Upper bound
Traditional	1	5.11 ( $\pm$ 0.76)	3.62	6.60
	2	3.50 ( $\pm$ 1.06)	1.42	5.58
	3	3.00 ( $\pm$ 0.65)	1.73	4.27
Servass	1	3.91 ( $\pm$ 0.49)	2.95	4.87
	2	2.20 ( $\pm$ 0.66)	0.91	3.49
	3	2.75 ( $\pm$ 0.84)	1.1	4.40
Drew	1	3.55 ( $\pm$ 0.46)	2.65	4.45
	2	2.85 ( $\pm$ 0.77)	1.34	4.36
	3	2.38 ( $\pm$ 0.63)	1.15	3.61
New Design	1	2.55 ( $\pm$ 0.42)	1.73	3.37
	2	2.50 ( $\pm$ 0.50)	1.52	3.48
	3	3.13 ( $\pm$ 0.95)	1.27	4.99



**Figure 5.** Mean numbers of lobsters landed using the traditional method of bait deployment, and bait deployed in the 3 types of bait saver for one, two and three day soak times, and their 95% confidence intervals.

**Table 2.** The test statistic (t-value), i.e. the difference between the mean numbers of lobsters caught using traditional bait deployment methods and each of the bait savers for both one and two day soak times, and the probabilities (based on the distribution of t-values generated using 20,000 randomisations of the pooled data) of these differences occurring by chance.

Treatment group	One day soak time		Two day soak time	
	t-value	Probability	t-value	Probability
Control vs Servass	2.97	0.00	1.04	0.15
Control vs Drew	2.05	0.02	0.50	0.32
Control vs New design	2.77	0.00	0.86	0.20

**Table 3.** Mean, upper and lower bound projected gross return per pot per lift (\$) across all treatment groups and soak times incorporating value of lobster at \$19 / kg (approx. \$9 per lobster) and bait costs of \$1.35 per kg but excluding the cost of the bait savers.

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Treatment group	Soak time	Lower Bound	mean	upper bound
Traditional	1	27.18	40.59	54.00
	2	7.38	26.10	44.82
	3	10.17	21.60	33.03
Servass	1	25.88	34.52	43.16
	2	7.52	19.13	30.74
	3	9.23	24.08	38.93
Drew	1	23.18	31.28	39.38
	2	11.39	24.98	38.57
	3	9.68	20.75	31.82
New Design	1	14.90	22.28	29.66
	2	13.01	21.83	30.65
	3	10.76	27.50	44.24

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**Table 4.** Mean, upper and lower bound projections of annual gross return of a commercial fisherman predominantly fishing offshore grounds with a 100-pot license incorporating 175 one-day pulls (65%) 25 two-day pulls (25%), 8 three-day pulls (10%). Upper value is using bait savers throughout the season, lower is for using bait savers only for two and three day soak times. Price of bait savers and bait for 100 pots included (*Servass saver* @ \$11.15 each (including one timer), i.e. \$1115 for 100 pot license; *Drew saver* @ \$5.50 each, i.e. \$550 for 100 pot license; *New Design* @ \$6.00 each, i.e. \$600 for 100 pot license).

Treatment group	lower bound	mean	upper bound
Traditional	502 236	792 855	1 083 474
Servass	477 969	670 074	862 179
	500 719	776 299	1 051 879
Drew	441 319	625 900	810 481
	511 319	788 825	1 066 331
New design	301 283	465 875	630 467
	516 183	786 300	1 056 417

**Table 5.** Mean, upper and lower bound projections of annual gross return of a commercial fisherman predominantly fishing inshore grounds with a 100-pot license incorporating 213 one-day pulls (85%), 12 two-day pulls (10%), 4 three-day pulls (5%). Upper value is using bait savers throughout the season, lower is for using bait savers only for two and three day soak times. (Price of bait savers for 100 pots included).

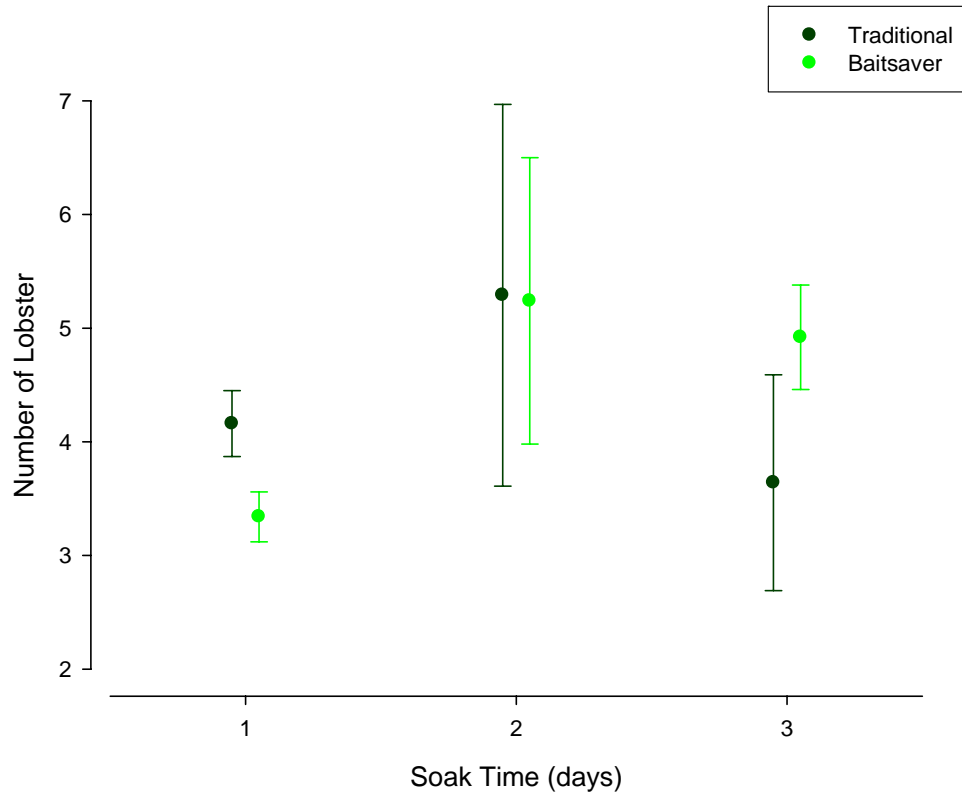
Treatment group	lower bound	Mean	upper bound
Traditional	591 858	904 527	1 217 196
Servass	562 845	766 749	970 653
	590 535	896 040	1 201 545
Drew	510 724	703 990	897 256
	595 924	902 293	1 208 662
New design	336 686	511 160	685 634
	598 250	901 163	1 204 076

**Table 6.** Mean, upper and lower bound projections of annual gross return of a commercial fisherman using lobster pots containing the modified new design bait saver (0.5 kg bait) in one bait box and one bait box packed in the traditional manner (2 kg fish bait). Gross returns are based on the results for traditional return per pot per lift figures for one and two-day soak times and those for the new design for a three-day soak time.

Treatment group	lower bound	Mean	upper bound
<b><u>Offshore</u></b>			
traditional + bait saver	542 608	837 403	1 132 342
Traditional	502 236	792 855	1 083 474
<b><u>Inshore</u></b>			
traditional + bait saver	637 057	951 814	1 266 643
traditional	591 858	904 527	1 217 196

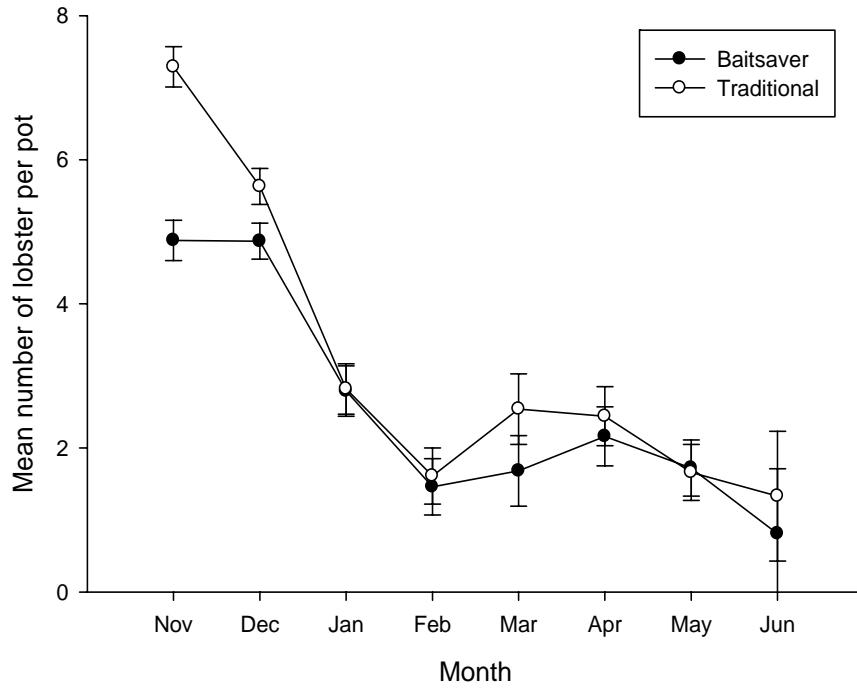
**Table 7.** Mean ( $\pm$  S.E.) and 95% confidence intervals of total lobster landed using the traditional method of bait deployment, and bait deployed in the bait saver for one, two and three day soak times across the 2005/6 commercial season.

Treatment group	Soak time	Mean ( $\pm$ S.E.)	95% Confidence Interval	
			Lower bound	Upper bound
Traditional	1	4.04 ( $\pm$ 0.12)	3.85	4.43
	2	5.33 ( $\pm$ 0.85)	3.63	7.49
	3	3.64 ( $\pm$ 0.63)	2.66	4.62
Bait saver	1	3.38 ( $\pm$ 0.12)	3.13	3.57
	2	5.27 ( $\pm$ 0.54)	3.99	6.53
	3	4.92 ( $\pm$ 0.84)	4.46	5.38



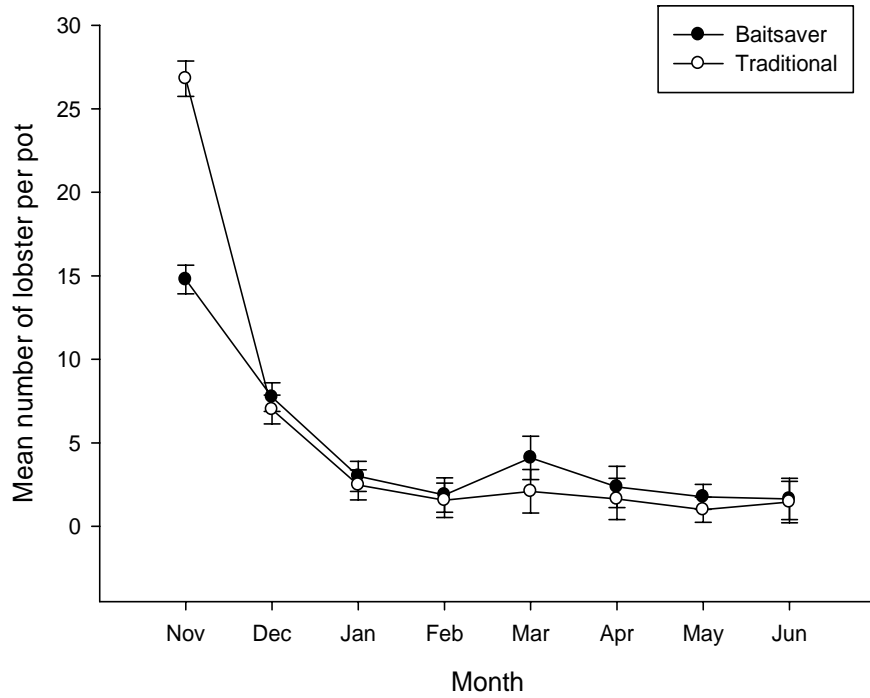
**Figure 6.** Mean numbers of lobsters landed using the traditional method of bait deployment, and bait deployed in the bait saver for one, two and three day soak times, and their 95% confidence intervals over the 2005/6 commercial season.

### Traditional vs Baitsaver One Day Soak Time



**Figure 7.** Comparison of mean  $\pm$  S.E of lobsters trapped using a bait saver and traditional methods across a one day soak time throughout the 2005/6 season.

Traditional vs Baitsaver Two day soak time



**Figure 8.** Comparison of mean  $\pm$  S.E of lobsters trapped using a bait saver and traditional methods across two day soak times throughout the 2005/6 season.

**Table 8.** Mean  $\pm$  S.E of lobster trapped using traditional methods and the bait saver across the one, two and three day soak times in the 2005/6 season.

Method	Soak time		
	1-day	2-day	3-day
Traditional	4.04 $\pm$ 0.12 <sup>a</sup>	5.33 $\pm$ 0.85 <sup>a</sup>	3.64 $\pm$ 0.49
Bait saver	3.38 $\pm$ 0.12 <sup>b</sup>	5.27 $\pm$ 0.54 <sup>a</sup>	4.92 $\pm$ 0.23

**Table 9.** The test statistic (t-value), i.e. the difference between the mean numbers of lobsters caught using traditional bait deployment methods and the bait saver for both one and two day soak times, based on both quasi-poisson and negative binomial distributions. An \* denotes significance at the  $P \leq 0.05$  level. An \* denotes significance at the  $P \leq 0.05$  level. (Dispersion parameter for quasi-poisson family taken to be 3.06). (Dispersion parameter for negative binomial family taken to be 1 with an estimated  $\lambda = 1.898$ ). These data are for the 2005/6 season.

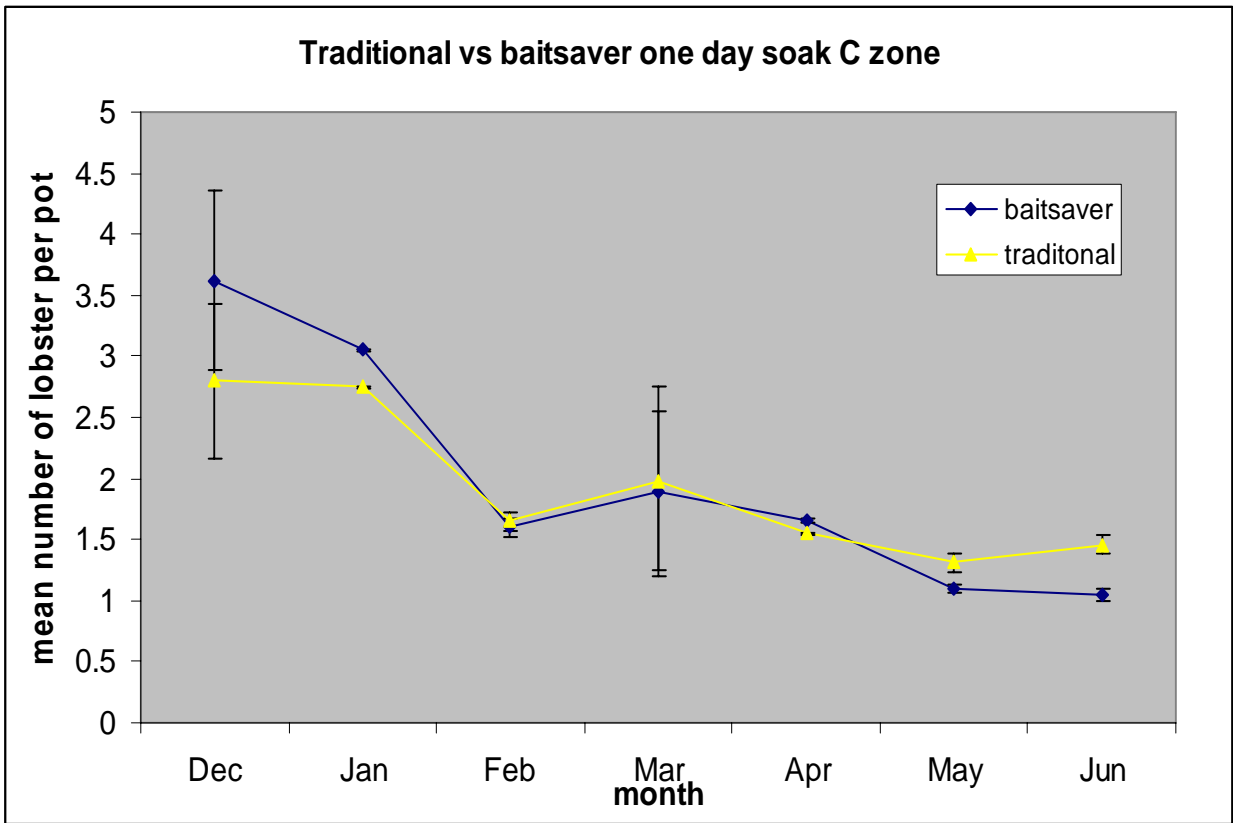
Model	Quasi-poisson		Negative binomial	
	1	2	1	2
Soak time				
Month				
1	0*	0*	0*	0.02*
2	0.63	0.6	0.04*	0.68
3	0.73	0.56	0.94	0.51
4	0.98	0.7	0.47	0.63
5	0.84	0.15	0.01*	0.11
6	0.72	0.49	0.1	0.4
7	0.33	0.15	0.79	0.05
8	0.35	0.84	0.19	0.8

**Table 10.** The test statistic (t-value), i.e. the difference between the mean numbers of lobsters caught using traditional bait deployment methods and the bait saver for both one and two day soak times, and the probabilities (based on the distribution of t-values generated using 20,000 randomisations of the pooled data for the 2005/6 season) of these differences occurring by chance. A test statistic (t-value) has also been derived via a GLM analyses based on both the quasi-poisson and negative binomial models. (An \* denotes highly significant results).

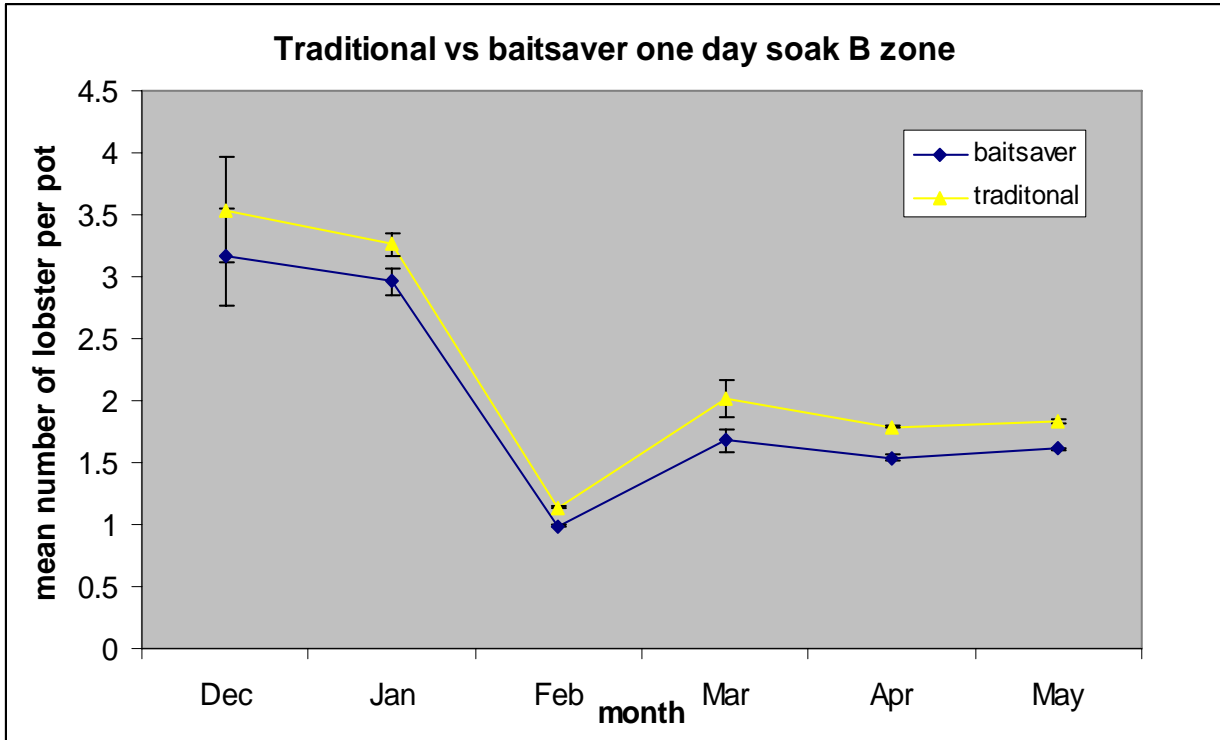
<b>Statistical test</b>	<b>One day soak time</b>		<b>Two day soak time</b>	
	t-value	Probability	t-value	Probability
Randomisation	4.85	0.00*	0.08	0.47
Quasi-poisson	4.13	0.00*	-1.48	0.14
Negative binomial	4.63	0.00*	-1.48	0.14

**Table 11.** Dispersion parameters and their respective AIC for each GLM investigating method of bait deployment, soak time and month for the 2005/6 season.

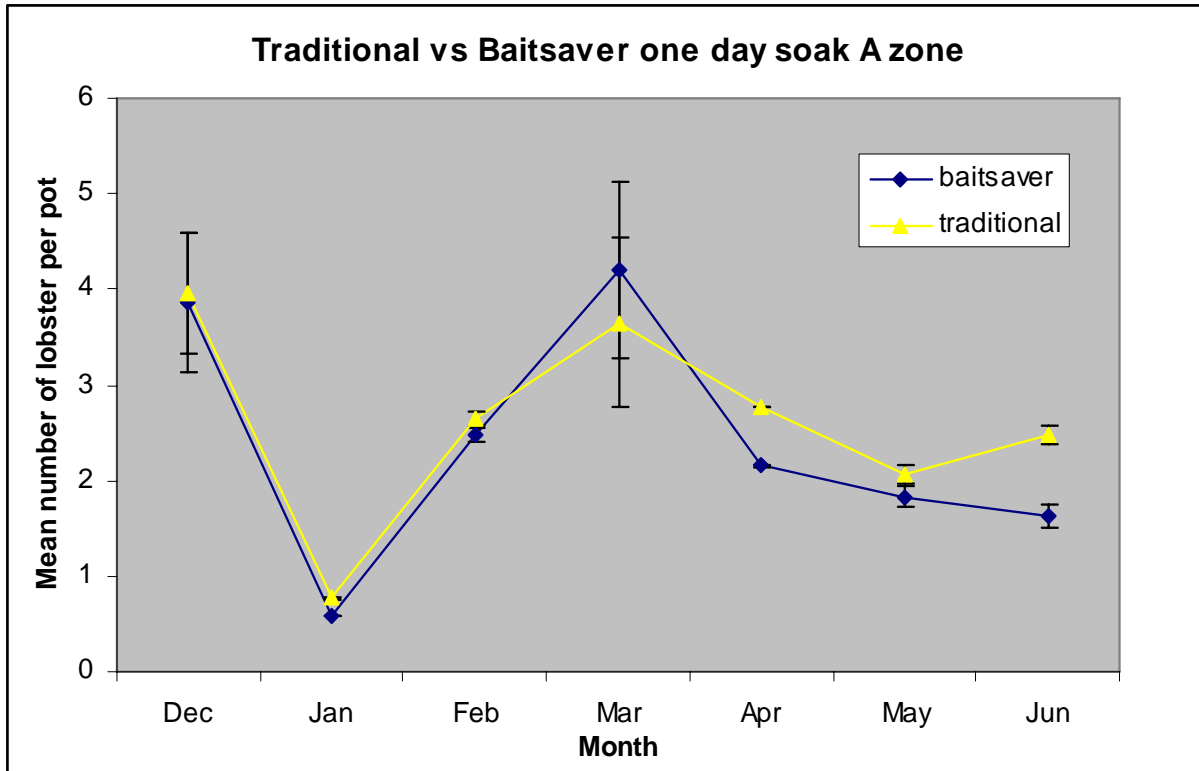
Model	Dispersion parameter	AIC
Poisson	1	13 531
Quasi-Poisson	3.06	NA
Negative Binomial	1.74	10 941



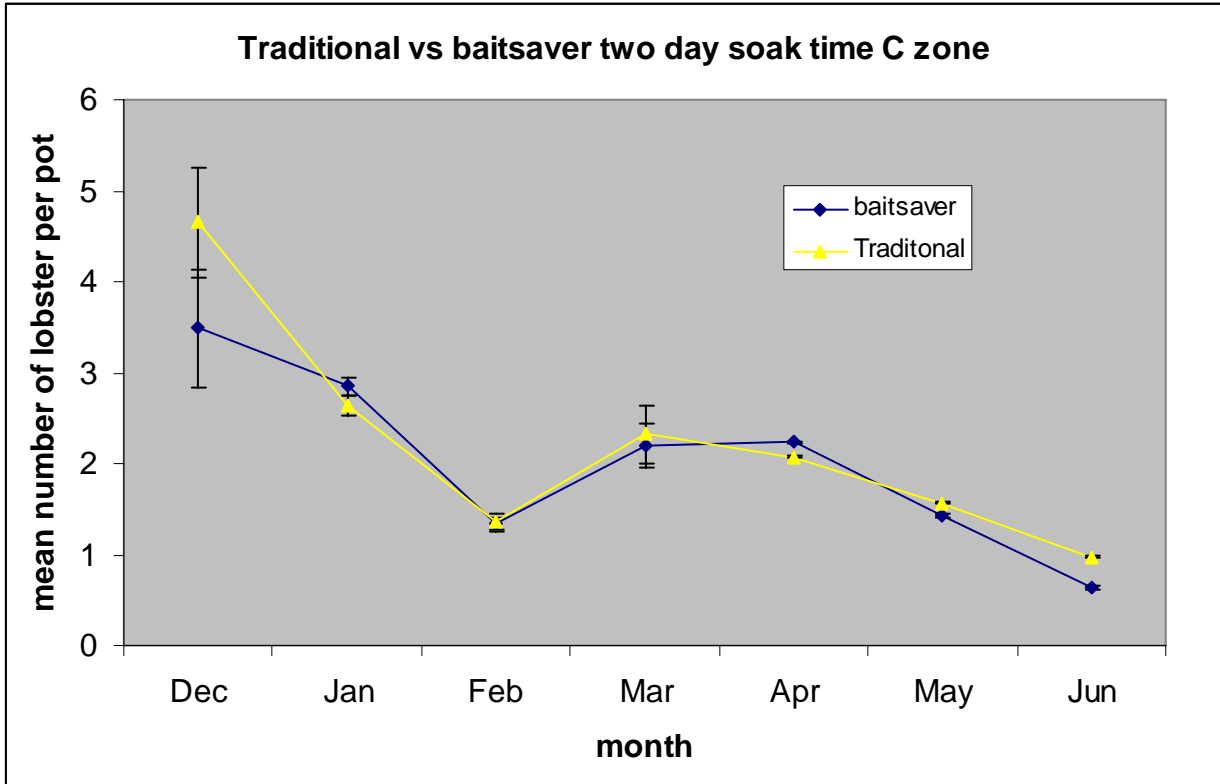
**Figure 9.** Comparison of mean  $\pm$  S.E of size (C.L. > 73mm) lobsters trapped using a bait saver and traditional methods across a one day soak time in zone C during the 2006/7 season.



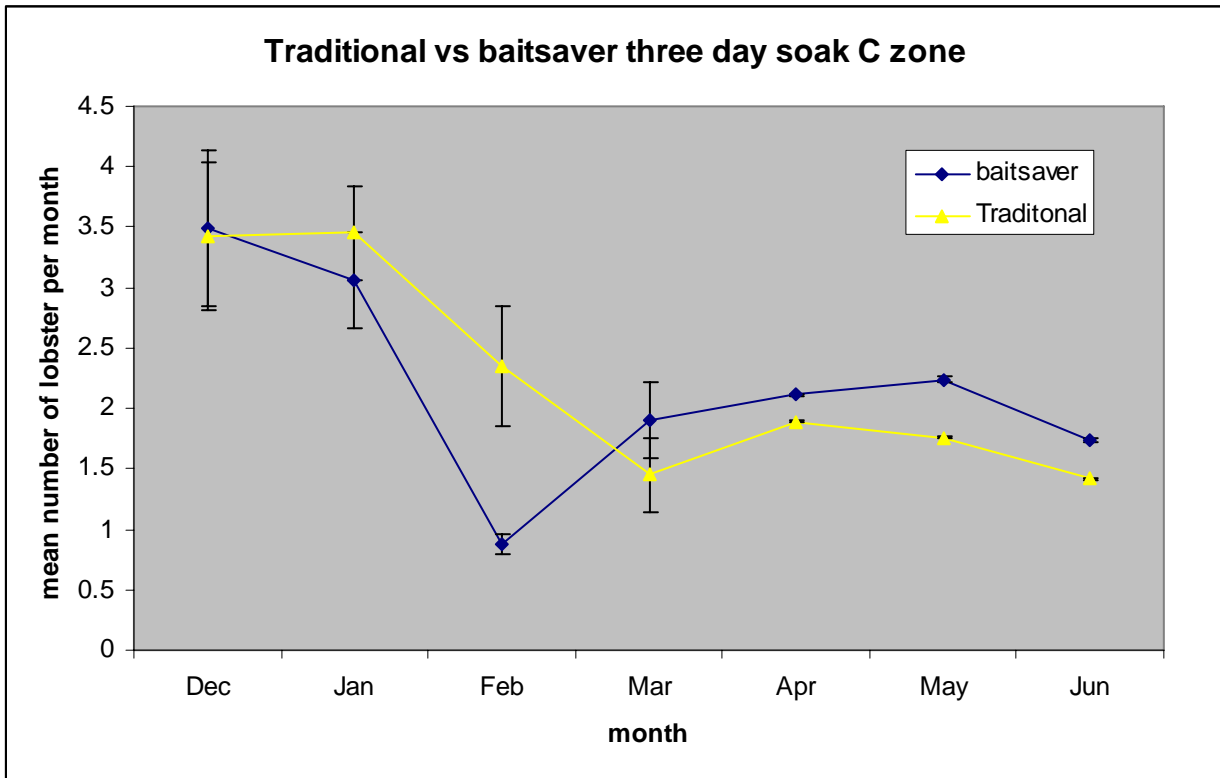
**Figure 10.** Comparison of mean  $\pm$  S.E of size (C.L. > 73mm) lobsters trapped using a bait saver and traditional methods across a one day soak time in zone B during the 2006/7 season.



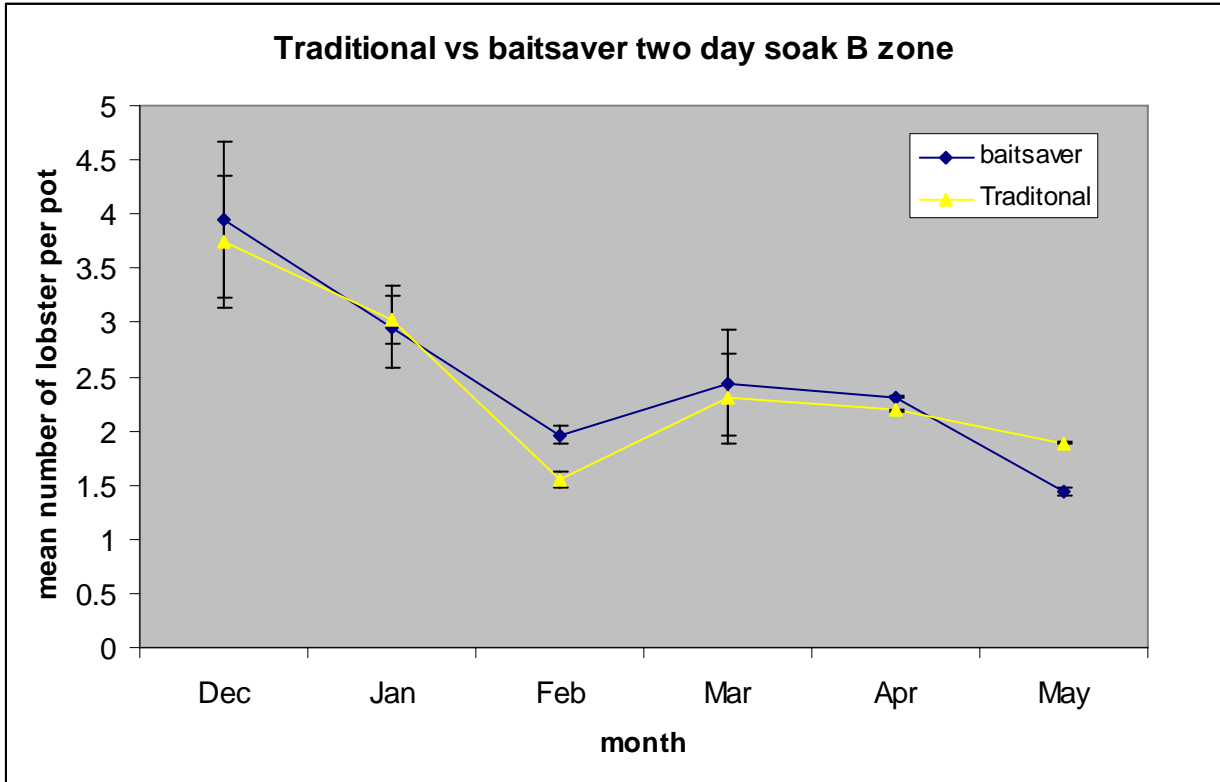
**Figure 11.** Comparison of mean  $\pm$  S.E of size (C.L. > 73mm) lobsters trapped using a bait saver and traditional methods across a one day soak time in zone A during the 2006/7 season.



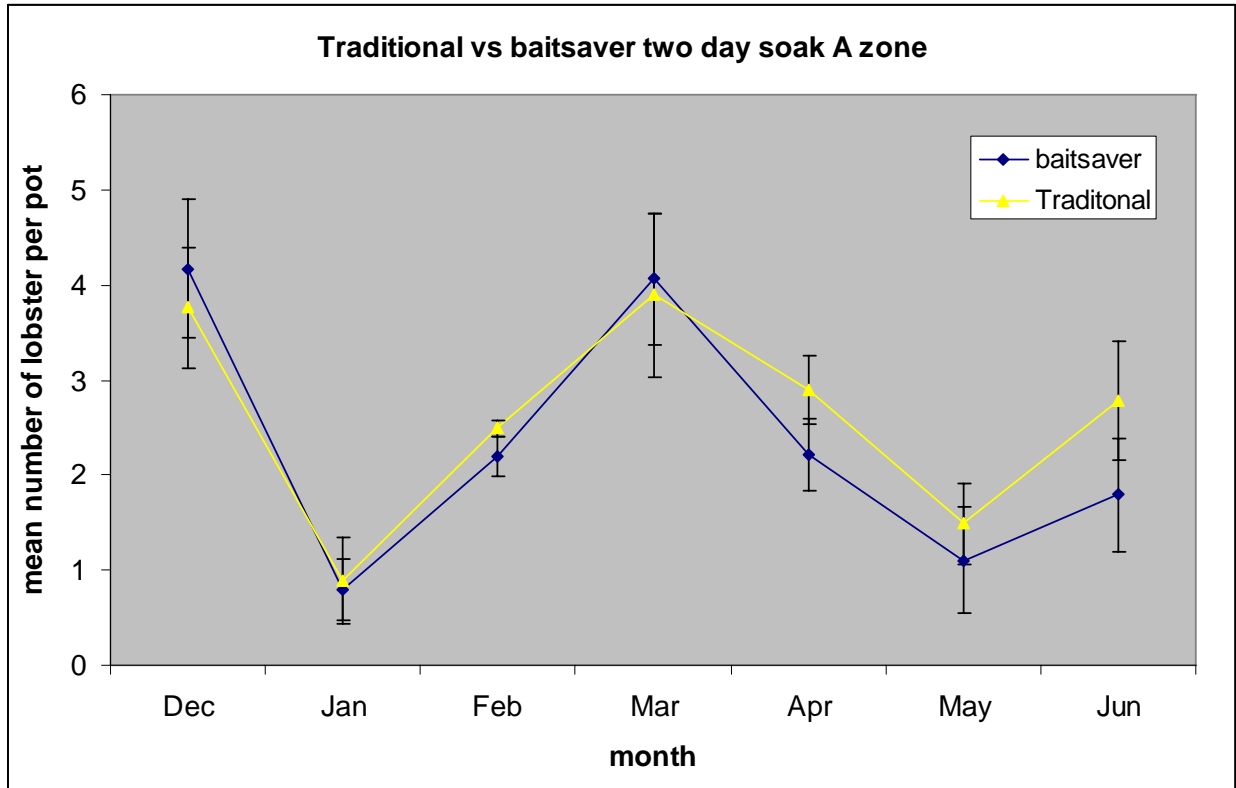
**Figure 12.** Comparison of mean  $\pm$  S.E of size lobsters (C.L. > 73mm) trapped using a bait saver and traditional methods across a two day soak time in zone C during the 2006/7 season.



**Figure 13.** Comparison of mean  $\pm$  S.E of size lobsters (C.L. > 73mm) trapped using a bait saver and traditional methods across a three day soak time in zone C during the 2006/7 season.



**Figure 14.** Comparison of mean  $\pm$  S.E of size lobsters (C.L. > 73mm) trapped using a bait saver and traditional methods across a two day soak time in zone B during the 2006/7 season.



**Figure 15.** Comparison of mean  $\pm$  S.E of size lobsters (C.L. > 73mm) trapped using a bait saver and traditional methods across a two day soak time in zone A during the 2006/7 season.

**Table 12.** Mean  $\pm$  S.E of size lobster (C.L. > 73mm) trapped using traditional methods and the bait saver across the one, two and three day soak times in zone C during the 2006/7 season.

Method	Soak time		
	1-day	2-day	3-day
Traditional	1.71 $\pm$ 0.24 <sup>a</sup>	2.23 $\pm$ 0.20 <sup>a</sup>	2.25 $\pm$ 0.28 <sup>a</sup>
Bait saver	1.88 $\pm$ 0.19 <sup>a</sup>	2.02 $\pm$ 0.16 <sup>a</sup>	2.20 $\pm$ 0.37 <sup>a</sup>

**Table 13.** Mean  $\pm$  S.E of size lobster (C.L. > 73mm) trapped using traditional methods and the bait saver across the one, two and three day soak times in zone B during the 2006/7 season.

Method	Soak time		
	1-day	2-day	3-day (n = 60)
Traditional	1.99 $\pm$ 0.24 <sup>a</sup>	2.45 $\pm$ 0.12 <sup>a</sup>	1.36 $\pm$ 0.58 <sup>a</sup>
Bait saver	2.26 $\pm$ 0.19 <sup>a</sup>	2.51 $\pm$ 0.21 <sup>a</sup>	1.79 $\pm$ 0.63 <sup>a</sup>

**Table 14.** Mean  $\pm$  S.E of size lobster (C.L. > 73mm) trapped using traditional methods and the bait saver across the one, two and three day soak times in zone A during the 2006/7 season.

Method	Soak time		
	1-day	2-day	3-day (n = 70)
Traditional	2.62 $\pm$ 0.24 <sup>a</sup>	2.60 $\pm$ 0.20 <sup>a</sup>	1.53 $\pm$ 0.72 <sup>a</sup>
Bait saver	2.39 $\pm$ 0.19 <sup>a</sup>	2.33 $\pm$ 0.16 <sup>a</sup>	1.66 $\pm$ 0.83 <sup>a</sup>

**Table 15.** The test statistic (t-value), i.e. the difference between the mean numbers of lobsters caught using traditional bait deployment methods and the bait saver for both one, two and three day soak times across all zones, and the probabilities (based on the distribution of t-values generated using 20,000 randomisations of the pooled data for the 2006/7 season) of these differences occurring by chance. A test statistic (t-value) has also been derived via a GLM analyses based on both the quasi-poisson and negative binomial models. (An \* denotes highly significant results).

Statistical test	One day soak time	Two day soak time	Three day soak time
Randomisation	0.68	0.47	0.38
Quasi-poisson	0.72	0.67	0.44
Negative binomial	0.65	0.4	0.69

