Managing inshore stocks of southern rock lobster for a sustainable fishery

Project No. 2009/058

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GLOSSARY

Double night shot: one shot set between the hours of 10pm and 3am on a given night that is part of a double night fishing event.

Double night fishing event: two paired double night shots set between the hours of 10pm and 3am on a given night.

Double night fishing trip: where at least one double night fishing event occurred throughout the length of the trip.

Standard fishing trip: where no double night fishing events occurred throughout the length of the trip

1 NON TECHNICAL SUMMARY

2009/058 Tactical research fund: Managing inshore stocks of southern rock lobster for a sustainable fishery.

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1.1 OBJECTIVES:

The overall objective was to examine whether changed fishing practices are responsible for declining rock lobster stocks. Specifically we aimed to:

1. Determine the extent of declines in the inshore stock by changing the current stock assessment model to assess stocks at a finer scale (<30m and >30m);
2. Assess whether increased effort in double night shots is adequately recorded in estimates of CPUE; include the differences in catch composition, size structure and the effects of handling on growth in assessments;
3. Assess the cost-effectiveness of double night fishing and compare short and long-term benefits;
4. Develop a management strategy evaluation, presenting options based on the results of the study.

1.2 OUTCOMES ACHIEVED TO DATE

The project has contributed the following outcomes:

1) An overview of the stock and double night fishing practices so that CFAC and DPIPWE can assess whether limiting or prohibiting double night fishing would result in different future biomass and CPUE estimates of inshore component of the stock.
2) A modified stock assessment model structure that could enables the inshore areas with most double night fishing to be assessed separately. This new structure is not yet used in assessments because growth data is currently inadequate at this scale. This data is being collected and the modified model will provide the basis for future

finer scale assessments once there is more detailed biological information.

3) Change in the format of the compulsory DPIPWE logbooks to provide better data on the timing of shots. This will permit double night fishing and other effort changes to be monitored as part of the annual stock assessment. It will also enable catch rate data to be standardized by timing of the shot, thus removing a presumed bias of assessments.
4) Guidelines for defining double-night fishing and options for legislation for use in any future management action.
5) This project delivered a CFAC and CRAG priority for assessing the impacts of double-night fishing.

The Tasmanian commercial southern rock lobster fishery (TSRLF) is a quota controlled pot fishery operating all around Tasmania. The annual commercial catch is around 1.5 million animals taken by approximately 230 vessels (Hartmann et al. 2010). In addition, there are approximately 21,000 licensed recreational fishers (Lyle and Tracey 2010). Inshore stocks have been declining for a number of years, and total legal biomass of the whole fishery has been in decline since 2007 (Hartmann et al. 2010). Fishing effort and life history demographics of the stock vary dramatically from region to region, and from inshore to offshore. This presents a number of challenges for fisheries assessment and management.

Serious concerns that fishing two shots per night (double night fishing) was depleting inshore stocks was raised by members of the southern rock lobster fishing fleet starting in 2007, through a range of forums. This concern heightened as state-wide fishing effort continued to rise while catch rates fell. Requests from the peak body TRFLA to ban it were complicated by the lack of scientific information on the effect and difficulty in defining a suitable approach to regulation and enforcement. As a result, the TRFLA requested that the Institute for Marine and Antarctic Studies (IMAS) conduct research into the practice of double night fishing.

It was not possible to determine the full extent of double night fishing in the rock lobster fishery using logbooks so depth logger and observer data from volunteer double night fishers were used to assess the extent of this practice. Of the 13 fishers who volunteered to participate in the depth logger study, only three fishers deployed two night shots on greater than 20% of their total days fished. Double night fishing was not widespread in the southern rock lobster fishery. There was no evidence from this survey that limiting or prohibiting double night fishing would result in different future biomass.

Fishers conducting double night shots had higher effort but this was modest in scale. The average number of shots per day on double night fishing trips (1.6 shots) was slightly higher than on standard fishing trips (1.5 per day) but trip length (days) was similar. A double night fisher completed an average of 3.4 more shots per trip than a standard fisher. Average soak time was lower in double night shots (9.5 hrs) than standard shots (12.5 hrs). While effort was slightly higher for double night fishing than standard fishing trips there was no difference in the CPUE. This indicated that was an economic advantage to fishers conducting double night shots because they achieved higher catches per unit of labour and capital. In a fishery with a constraining TACC, increasing efficiency by reducing fixed costs makes the fishery more profitable. This observation also implies that fishers conducting double night shots would be able to remain viable in situations with lower catch rates, such as in depleted inshore areas. This was consistent with the original concern of industry but critically the scale of the effect seemed small.

Mean length of lobsters caught in double night shots was 2.5mm higher than in standard shots; however the variation in lobster length per month was up to 30 mm which is far larger source of variability. The abundance and diversity of bycatch between double night and standard shots were similar, and mortality of lobsters caused by octopus in pots was lower on double night shots. This practice did not increase damage due to handling or discarding. Growth of lobsters from all types of fishing that sustained an injury such as limb loss was reduced by 0.6 mm yr^{-1} for females and 1 mm yr^{-1} for males. As double night fishing did not increase the amount of damage to lobsters, then it appeared no more likely to reduce growth rates through injury and discards than standard fishing.

Our best evidence suggests that of the effect of double night fishing effort on inshore biomass is minor relative to the larger issue of total catch (and thus effort) as regulated through the TACC. Damage due to handling and discarding appeared reduced through double night shot fishing because average weight of lobsters was slightly higher (thus fewer lobsters per unit quota) and catch rates were equivalent to standard night shots. In 2010/11 double night shot fishing did not appear to be as widespread as discussed prior to the project. Interestingly, many fishers who self-identified as double night shot fishers actually rarely conducted this type of fishing. Rather, they sometimes set and haul their gear late in the middle of the night, rather than completing two full shots during the night.

It is difficult to determine whether we have captured the true extent of this activity without broader participation of the fishing fleet and clearer recording of shot times in the logbook. As a result of the is project the logbook is to be adjusted so that fishers no longer record

'shot type' and 'date of month' and instead record the time and date of first pot set and first pot hauled for each shot. The logbook also is also to be amended to prevent shots being combined across a calendar day by reporting double the number of pots. This would allow assessment of fine-scale effort, and correction for potential bias from double night shot fishing in the stock assessment process for the fishery.

1.3 KEYWORDS

Southern rock lobster, effort, growth, bycatch, CPUE, double-night fishing, inshore depletion

2 ACKNOWLEDGEMENTS

We acknowledge the Seafood CRC which supported Tim Emery on a PhD Scholarship which contributed to this research and allowed us to expand the goals. We also acknowledge the Tasmanian Rock Lobster Fishing Industry who financially supported this project as well as voluntarily participated in this research by taking observers on-board their vessels and by attaching data loggers to their pots. We thank Gary Carlos, Scott Mason, and Chris McKinley for assistance with observer work on boats.

3 BACKGROUND

Serious concerns over the effects of two shots per night (double night fishing) and the depletion of inshore component of the stock have been raised by members of the southern rock lobster fishing fleet over the last five years through a range of forums. In 2007, through the Crustacean Fishery Advisory Committee (CFAC), industry first flagged the issue. This resulted in a discussion paper of the key issues surrounding this practice which, along with a questionnaire gauging the broader fishing community's concern, was distributed in April 2008. There were 97 respondents to the questionnaire of which 26% practiced double night fishing and 65% were concerned about the practice. In July 2008 the CFAC considered the responses to the questionnaire, determining that it was a serious issue, but there was not enough industry support to pursue a legislative outcome. In a meeting in October 2008 the Tasmanian Rock Lobster Fishermen's Association (TRFLA) passed a motion that double night fishing should be banned. TRFLA posted the results of this vote to the Department of Primary Industries, Parks, Water and Environment (DPIPWE) requesting a ban on this practice. DPIPWE responded, acknowledging that there was not enough scientific evidence to determine whether double night fishing has detrimental effects, and requested TRFLA to consider how it could be regulated. TRFLA urgently requested that the Institute for Marine and Antarctic Studies (IMAS) conduct research into the practice of double night fishing.

4 NEED

There is clearly a concern in the Tasmanian lobster industry about the status of the inshore component of the stock. Catch has declined in a number of areas, despite improvements in catch rates. In the Northeast, catch is at record lows, but catch-per-unit-effort (CPUE) has remained stable, which is a possible indicator of hyper-stability or false stability. This is where apparent stability in catch rates occurs because aggregations containing a major proportion of the population are fished down, as the fleet moves from one area of good catch

rates to the next, resulting in a serial depletion of the aggregations, which is masked by the apparent stability in the fishing block. This can result in a very sudden decline in biomass once the entire block is depleted, posing a serious and immediate risk to the inshore component of the stock. In the Tasmanian southern rock lobster fishery there are two potential risks in failing to identify such a problem. Firstly, the scale of the current assessment model, of eight inshore areas (<64m) and three offshore areas (>64m) is not fine enough to detect localised changes in the CPUE or biomass. Secondly there are changes in fishing practices that have increased effort on inshore stocks, and it is unclear whether the extra effort in these practices is adequately recorded in estimates of CPUE. There has been a recent change in fishing practice, thought by industry to result in an increase in potting effort, commonly referred to as double night fishing, whereby fishers set and haul their pots twice a night, compared to the standard practice of emptying pots once at dusk and/or once during the day. Currently we have no data on the composition of the catch in double night shots, and what proportion of captured lobsters are handled and released, and in fact what consequence this handling has on the overall health of the fishery.

5 OBJECTIVES

The overall objective was to examine whether changed fishing practices are responsible for declining rock lobster stocks. Specifically we aimed to:

1. Determine the extent of declines in the inshore stock by changing the current stock assessment model to assess stocks at a finer scale (<30m and >30m);
2. Assess whether increased effort in double night shots is adequately recorded in estimates of CPUE; include the differences in catch composition, size structure and the effects of handling on growth in assessments;
3. Assess the cost-effectiveness of double night fishing and compare short and long-term benefits;
4. Develop a management strategy evaluation, presenting options based on the results of the study.

6 METHODS

6.1. Examine declines in inshore stock by changing the current stock assessment model to assess stocks at a finer scale.

Methods: The current model used to generate stock assessments of the southern rock lobster stock in Tasmania was to be modified to assess the stock in 19 areas rather than the existing 11 areas. The current model assesses the stock using eight inshore areas, below 64m and three offshore areas encompassing fishing grounds >64m (Fig.1). Through this

project we will further divide the eight inshore areas into 16 areas, delineating the existing areas at 30m. Economic data will also be split at this scale to allow cost-benefit analyses of the change to inshore fishing and double night shots.

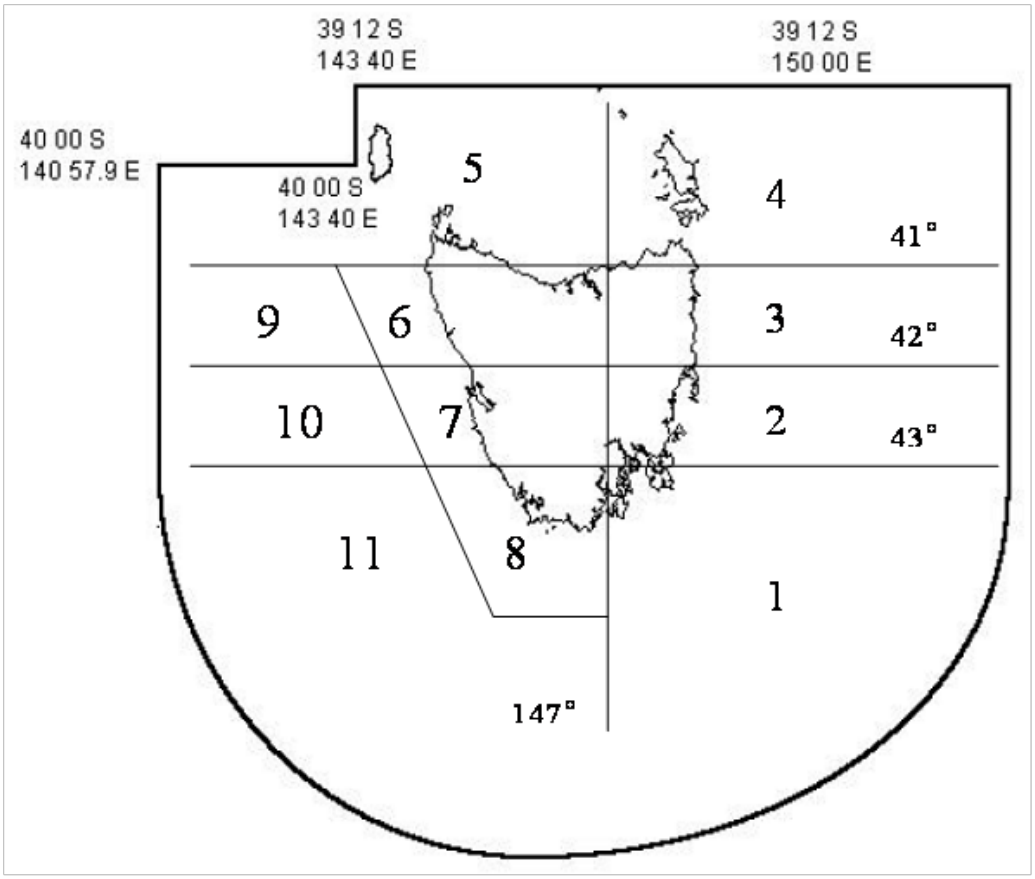


Figure 1. Map of Tasmania with southern rock lobster stock assessment areas numbered 1-11.

6.2. Assess whether increased effort in double night shots is currently recorded in estimates of CPUE.

This objective required three approaches to determine whether the extra fishing effort in double night shots was adequately recorded in the DPIPWE logbooks, and ultimately was captured in the stock assessments estimates of CPUE.

i. Compare the effort recorded by observers to the effort reported in the compulsory DPIPWE logbooks, assessing whether the logbook format is adequate and the reporting is comprehensive.

Methods: We extended our existing observer program to include boats fishing two shots in a night. Observers collected data from six observer trips, representing 67 days fishing on vessels undertaking double night shots. Observers used a headset and recording device to record the details of all of the lobsters caught. Details included tag number (new or previously tagged), size, sex, colour, maturational status, damage to limbs and carapace, shell condition. Higher order data on shot depth and location, number of shots and time of shooting and hauling were also recorded.

Defining double night fishing

To discern whether a shot is a double night or standard shot we examined the time of set and haul. The logbook does not provide this information so the data from depth loggers (see below) was used to formulate a suitable definition and compare fishing behaviours recorded in the logbook with fishing behaviour recorded on the boat. The definition of a double night fishing event used in this report is where a fisher hauls and then resets their pots between the hours of 10pm and 3am on any given night. Thus a double night fishing event is always two paired shots within the one night. This definition was chosen because it encompassed a greater number of double night shots than alternative time slots.

ii. Record double night fishing activity using data loggers on pots and compare this to effort recorded in the logbooks

Methods: The names of 25 fishers thought to practice double night fishing were provided by the TRLFA. These fishers were then contacted and asked whether they would be willing to participate in the project by deploying data loggers. In total 13 fishers assisted with data collection using the loggers across 2010 and 2011. These fishers were provided with full briefing details and two data loggers, which were attached to two pots. The data loggers were retrieved at regular two month intervals to download records of fishing activity and then returned to fishers.

The Sensus Ultra data loggers recorded the following variables at 60 second intervals:

- PSI (pressure), which was used to determine depth of the pot and therefore whether a pot was onboard or set underwater
- Time
- Water temperature

The data collected was then downloaded into a secure IMAS depth logger database. The sampling period reflects fishing trips completed between May 2010 and March 2011, not including the Tasmanian SRL fishing season closure between 30 September and 15 November 2010.

We examined the level of reporting by comparing the total number of shots recorded in the logbooks and depth loggers. The format of the logbook allows a fisher to report two shots across a calendar day as one by simply summing the number of pots this was separated in the analysis. For example, some double night fishers record a single 100 pot shot in their logbook to signify two double night shots. The level of reporting of shots in both the logbook and depth logger was assessed across all volunteer fishers.

Using the depth logger data we examined whether there was any difference in the (i) mean number of shots per day and length of trip (ii) CPUE and (iii) soak time of double night and standard shots and/or fishing trips with the effect of individual fisher and month of trip included as additional factors. The change in percentage of catch from night shots in inshore areas was also examined by dividing the fishery into 29 inshore 30' x 30' blocks using the DPIPWE logbook.

iii. a. Record the size structure and composition of night-time shots.

Using observer data collected from observer, outlined above, we examined (i) whether there was any difference in the size structure of double night shots compared to standard shots (day and night) and night shots; (ii) whether there was any difference in the discard rate between double night and standard shots; and (iii) whether there was any difference in the by-catch composition of double night and standard shots in terms of abundance and diversity. We also examined the rate of octopus-induced mortality. The data was acquired from IMAS long-term rock lobster database (CRAYBASE) for these analyses.

b. Assess whether capture increases limb loss; and limb loss influences growth

Methods: We directly compared the rate of injury between standard and double night shots before examining whether there was any cost of injury to growth using CRAYBASE by comparing annual growth rates of both male and female lobsters who had moulted at least once prior to the first recapture. Geographic variation in growth was also included in this analysis. Males were assumed to moult between August-October and females between March-May each year. A male or female lobster that was initially caught in those months was

assumed to have moulted already that season and if recaptured in those months was assumed to not yet have moulted.

6.3. Assess the cost-effectiveness of double night fishing

Methods: We would incorporate any of the results from Aims 1 and 2 into the Tasmanian rock lobster stock assessment model and bio-economic model and assess the cost and benefit of different fishing scenarios.

6.4. Develop management strategy evaluations based on the outcomes of the project.

Methods: While we had anticipated a formal management strategy evaluation, the results were such that this wasn't required. Instead we consulted with industry about the methods to determine whether the logbooks adequately recorded fishing effort and changes in fishing effort. Outcomes were presented to the CFAC and DPIPWE at CFAC 53 in March 2011.

7 RESULTS/DISCUSSION

7.1. Determine whether double night fishing may be causing declines in stock

Potential mechanisms for double night fishing to influence stock abundance.

One of the key goals of this work was to determine whether the extra effort reported to occur due to the change in fishing practice of double night fishing was adequately recorded in estimates of CPUE. If the changed fishing practice referred to as double night fishing by the Tasmanian rock lobster fishing industry was resulting in a decline in stock, then the possible mechanisms for this would be that it: 1. resulted in an increase in effort and 2. increased catch per unit effort. We examined each of these.

Effort

At the outset, we presumed that double night fishing resulted in an increase in fishing effort as it was reported to double the number of shots a fisher undertook on a given night. Through 12 months of sampling we found only a slight increase in effort through this practice (Fig. 2). There was no information on the spatial distribution of double night fishing. Inshore catch rates have declined as have all catch rates throughout the fishery.

Effort was assessed in three ways: (i) observers onboard vessels where the skipper had volunteered that they undertook double night fishing; (ii) depth loggers attached to pots on boats undertaking double night fishing; (iii) analysis of compulsory industry logbooks. The

most comprehensive source of data was from the depth loggers which recorded 1029 fishing shots (up to February 2011), recording the times of each pot set and hauled during a trip. The average number of shots per day was slightly higher (1.65 ±0.06 shots per day) on double night fishing trips than standard fishing trips (1.49 ±0.04 shots per day, $F_{1,62}$=12.32, p < 0.001, Fig. 2a).

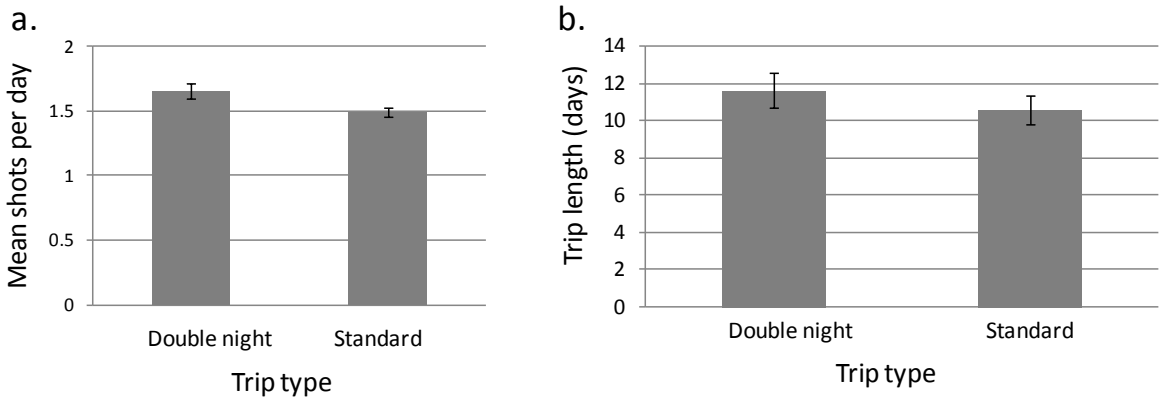


Figure 2: Effort comparison (mean ±SE) of a. shots per day and b. trip length between double night and standard fishing trips from depth logger data.

There was no difference in the length of trip between trips undertaking double night fishing or standard fishing. ($F_{1,16}$=1.57, p > 0.05, Fig 2b). For most months the length of both double and standard night fishing trips was similar, although in August double night fishing trips were longer (Fig. 3).

We had expected that double night fishing would encompass three shots per day – two overnight in addition to a day shot. Instead we found that many fishers who classify their fishing practices as double night fishing did a maximum of two shots in a day, and often only one shot per day. The key difference in their fishing behaviour is that they haul and reset their pots during the night, rather than in the morning like fishers undertaking the standard and widely accepted day and night shot.

Double night trips had an average of 3.5 shots per trip more than standard trips (Fig. 4a). Not surprisingly, to fit these extra shots in, soak time was lower on double night trips (Fig. 4b).

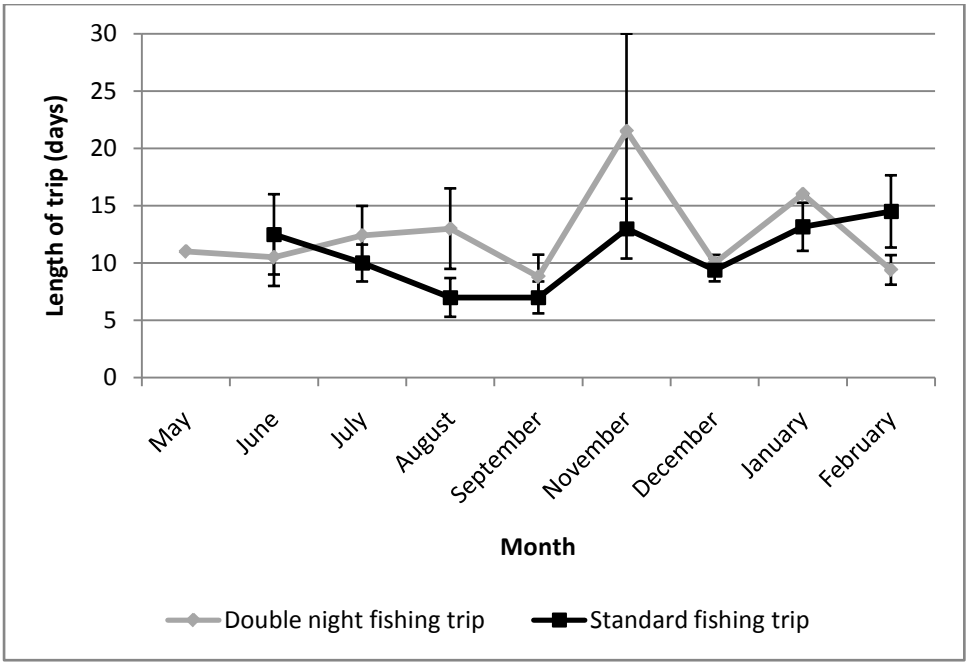


Figure 3: Trip length (mean ±se) length (days) of double night fishing trips compared to standard fishing trips by month.

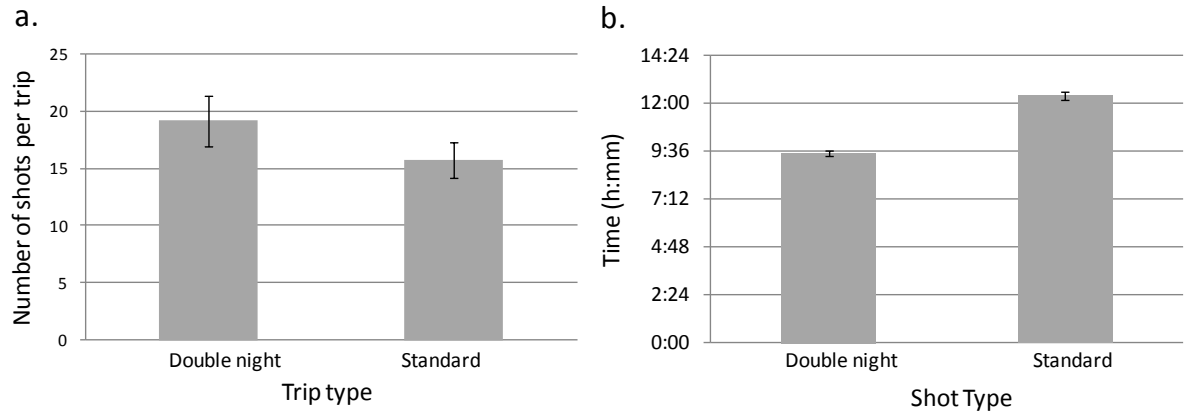


Figure 4: A comparison of a. number (mean ±se) of shots per trip and b. soak time in double night fishing compared to standard fishing.

Catch

The proportion of the catch from the fishery taken in night shots has varied since 2000, ranging from 73% to 83% (Fig. 5). It was highest in 2010 and second highest in 2001, suggesting recent changes in fishing practices are not the sole cause of the increase in the proportion of catch taken at night. There are other changes in fishing behaviour that have occurred over the past ten years. Out of the 29 fishing blocks used to report catch and effort, there were increases in the percentage catch from night shots of 23 by an average of 8.46%

(Fig. 6). The greatest proportional increases in night catch were in south and south-east areas of the State (Fig 6).

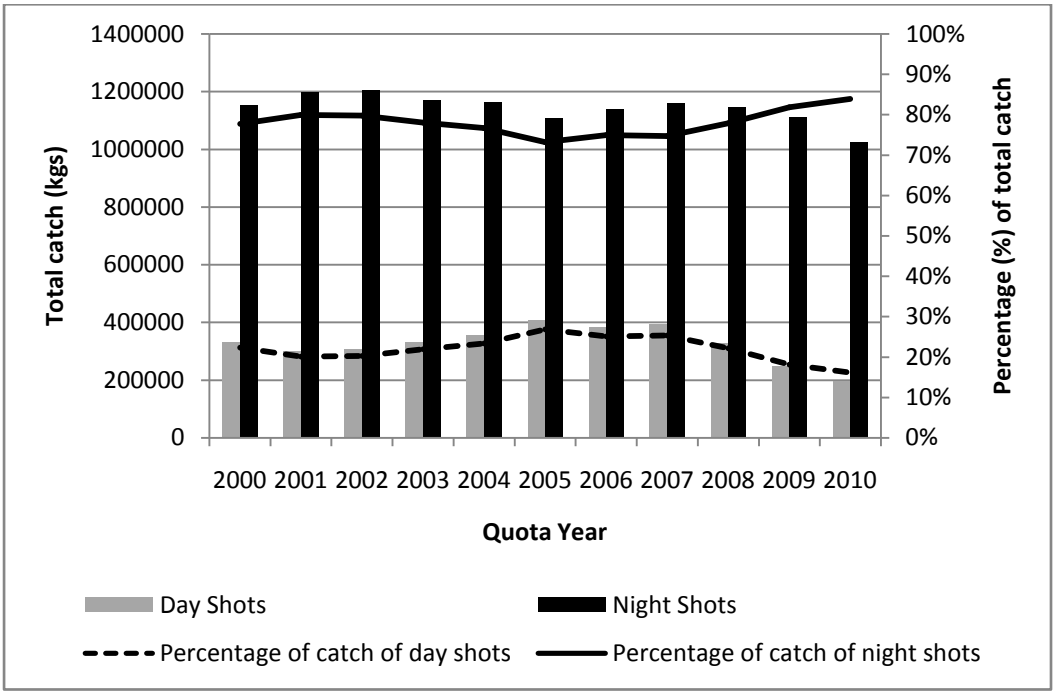


Figure 5: Total catch and percentage of total catch of night and day shots between 2000 and 2010 quota years

CPUE

There were a total of 426 out of 1,424 shots from depth logger data which could be matched to the logbook on a shot-by-shot basis, encompassing only 40 of the 246 double night shots recorded by the depth loggers. There was no difference in CPUE for double night shots and standard shots (F_1=0.88, $p > 0.05$, Fig. 7).

Stock abundance

Prior to this project the stock assessment model contained 11 assessment areas, 8 inshore and 3 offshore on the west coast deeper than 64 m (Fig. 1). We had planned to further divide inshore stocks above and below 30m to provide a higher resolution for inshore areas. This split was attempted; however there were insufficient tag returns from individual areas once the split was carried out to obtain reliable estimates of growth rates, recruitment and movement between areas. Consequently, results from the divided model were too unreliable to provide useful information.

There are recent declines in biomass in all areas, except area 10 (Fig. 8a). These trends are a function of both growth of legal-sized stock and low recruitment of new lobsters in to the

stock (Hartmann et al. 2010). Fishers were concerned that an increase in multiple night shots was masking real trends in catch rate data. To address this concern an analysis of catch rates restricted to day shots only was conducted. This analysis showed that overall catch rates declined by 13% state wide, and catch rates for day shots declined by 19% statewide (Hartmann et al. 2010).

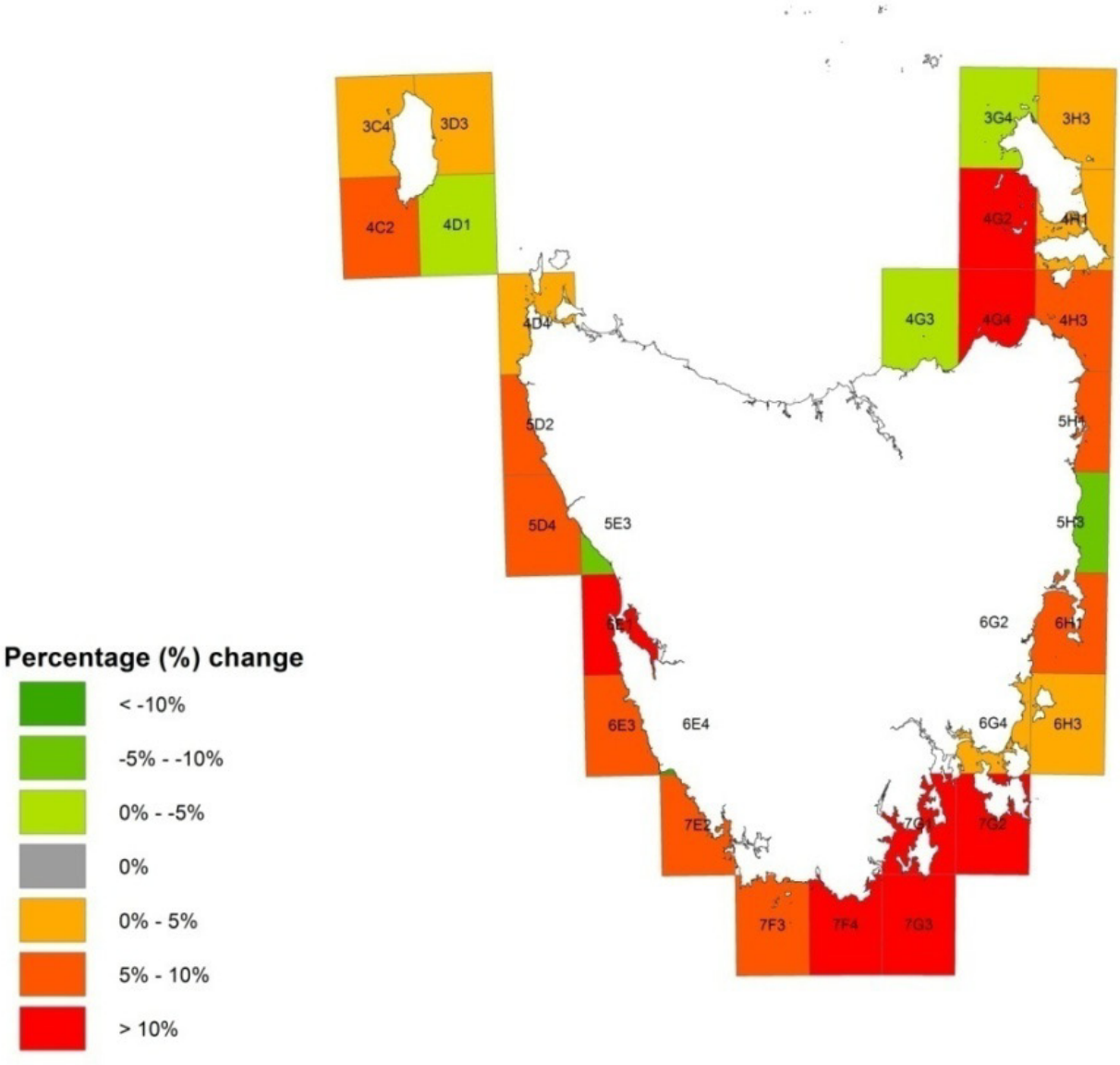


Figure 6: The change in percentage of night shot catch taken from inshore areas between 2005 and 2010 quota years.

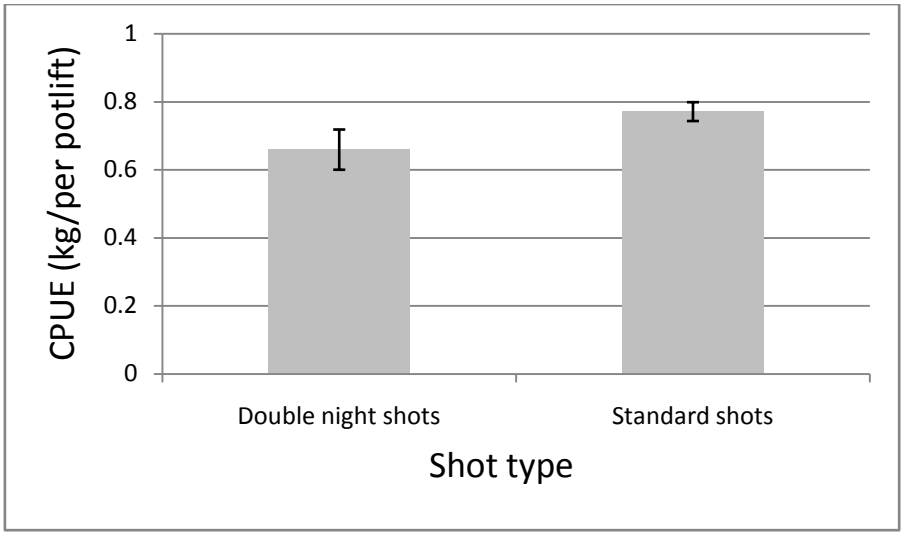
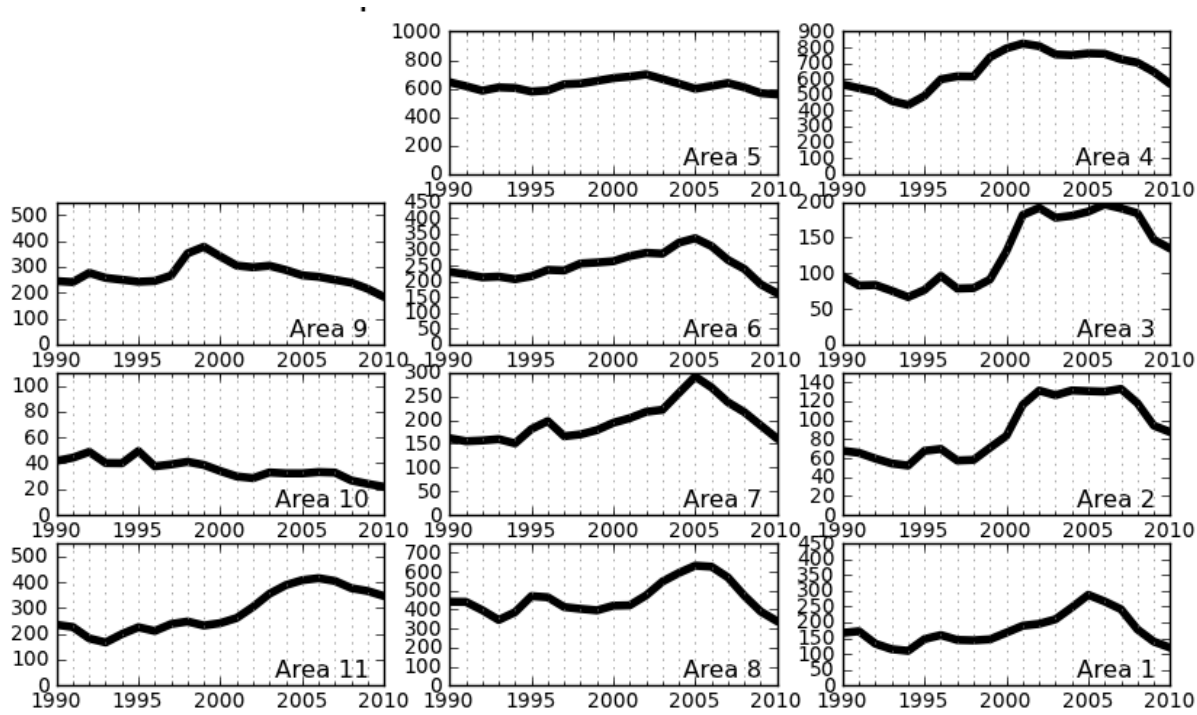


Figure 7: CPUE (mean ± se) of all double night shots compared to standard shots from depth logger and logbook data

Fishers were also concerned that an increase in inshore fishing (partly due to double night fishing) was masking real trends in CPUE as these areas were seeing greater CPUE decline than elsewhere. Catch rates have been decreasing in both deep and shallow water at similar rates throughout most of the state (Fig. 8b).

a.



b.

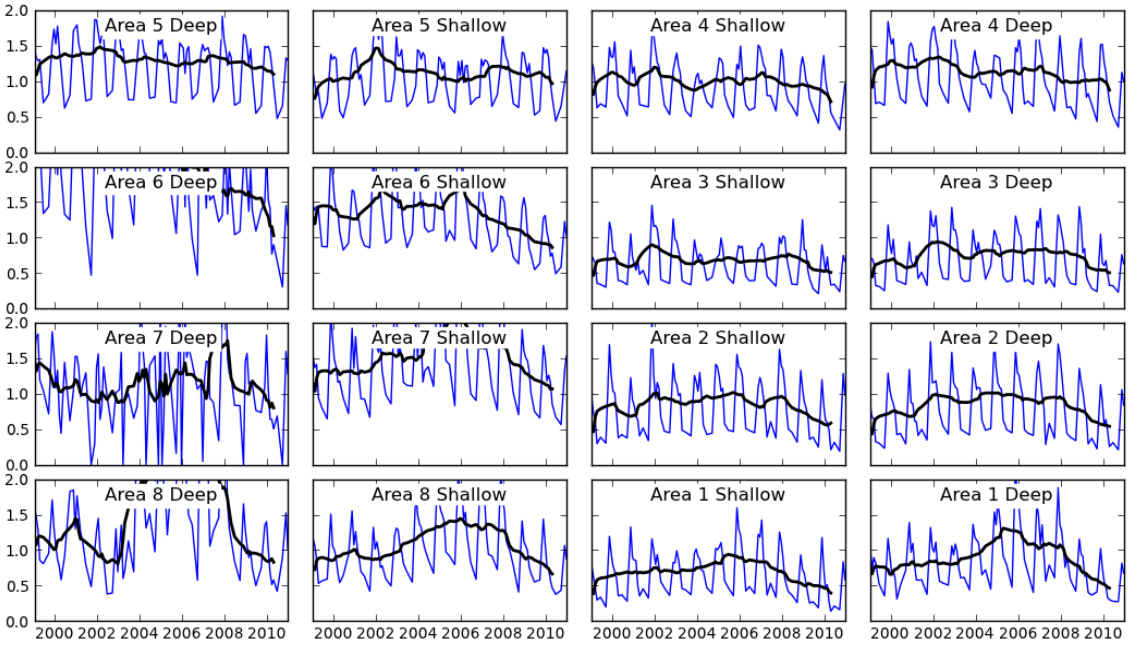


Figure 8. Biomass and catch rates in the Tasmanian rock lobster fishery by area. a. Exploitable biomass (tonnage of legal sized fish estimated from stock assessment model), b. CPUE in the eight areas split by depth. The blue line shows the monthly CPUE with clear seasonal trends whilst the black line shows the average annual CPUE. CPUE has been declining substantially in all areas, regardless of depth, since the mid 2000s. Area's 9-11 are deep water areas, area's 5-8 are west-coast inshore shallow water areas (below 64m) and areas 1-4 are east coast areas (Fig. 1).

7.2. Assess whether increased effort in double night shots is currently recorded in estimates of CPUE.

Compare the effort recorded by observers to the effort reported in the DPIPWE logbooks assessing whether the logbook is adequate.

As part of the rock lobster licensing requirements from DPIPWE, it is compulsory to fill in standardised logbooks for all fishing catch and effort. Within the current structure of the logbook it is not possible to determine the extent of double night fishing, how many double night shots have occurred or when they were most likely to occur. It was originally envisaged that a double night fishing event could be defined as either three shots (day or night) or two night shots within a calendar day. There is no evidence from the logbook database however of fishers reporting more than two shots or two night shots within a calendar day. It is therefore not possible to identify double night shots in the logbooks using a definition based on number of shots on a calendar day. The most appropriate method for distinguishing double night from standard shots is to develop a definition using the time of set and time of haul, however the logbook does not require fishers to record this information. Fishers only need to record the 'shot type' (day or night) and 'date of month' (calendar day).

While the current structure of the logbook does not preclude a fisher from recording two night shots on the same calendar day it is made improbable because at midnight (or between night shots) it becomes a new calendar day. For example, a fisher could set their pots at 3pm then haul them at 11pm on the 1 January and then re-set them at 1am and re-haul them at 7am on the 2nd January. While this is undeniably a double night fishing event and both shots could be classified as night shots under the definition, they will be recorded across two separate calendar days. It is not possible to determine whether a fisher reset them on the same night as in the example above on 1/2 January or whether they set them early on the following night of the 2/3 January.

This problem is further complicated by the dramatic seasonality changes in Tasmania, which could mean a shot classified as night in winter could be day in summer due to the large differential in the amount of daylight between seasons. For example, a fisher sets their pots at 3pm and then hauls them at 11pm on 1 July before re-setting them at 1am and re-hauling them at 10am on 2 July. Both shots are night shots, but if the date was 1 December, both shots would be day shots. This makes it difficult to create a definition based on the type of shot. Two further issues with the structure of the logbook is the ambiguity in the current

definition of 'date of month' or calendar day and reliance on fishers estimating the amount of day and night time across a long soak time to determine the correct 'shot type'.
The current definition of 'date of month' in the logbook gives no guidance on whether a fisher who sets their pots at 9pm on 1 January and hauls them at 3am on 2 January should record this fishing event as taking place on the day of the set or haul. This ambiguity and resulting lack of consistency among fishers further complicates the classification of double night fishing events.

The number of shots across each trip from the depth logger was compared to the logbook to assess the level of reporting. The level of under-reporting was low in the logbook (< 1 shot per trip), indicating that the total number of shots are appropriately recorded by fishers. Importantly this indicates that the reporting of double night fishing is not leading to biases in the estimates of CPUE. The configuration of the reporting often followed the logbook instructions which allow two shots of 50 pots to be recorded as a single shot of 100 pots, a method of recording which still correctly captures the amount of catch and of effort.

Out of a total of 425 shots that could be matched from the depth logger to the logbook, 84% of fishers correctly recorded the shot type. When just examining the correct classification of double night shots there was an accuracy rate of 69% across 39 fishing shots. There was a mis-classification of shot type more frequently for double night shots than for standard shots.

Alternative methods of investigating double night fishing.

The depth loggers recorded a total of 84 fishing trips in the TSRLF, which included 1,424 shots, of which 246 were double night shots. Out of the 13 fishers who participated (volunteering because they identified as double night fishers) only three undertook double night fishing on greater than 20% of their total days fished (Fig. 9a). This is a clear indication that DNS was not as widespread as initially thought, or at least not during 2010/11. There were a total of six observer trips on vessels undertaking double night fishing. Of these, double night fishing occurred on more than 40% of the fishing days on only four trips (Fig. 9b), however it should be noted that three out of those four trips were on the same vessel.

Record the size structure and composition of night-time shots

There was a minor difference in the size of lobsters caught in double night shots (DNS) compared to standard fishing (Fig. 10a). Lobsters from DNS were longer by 2mm (mean carapace length, mm), however there was up to a 30mm difference in the size of lobsters

caught between December and August (Fig. 10b). Fishing month had a much larger effect on the size of the lobster caught than fishing type (Fig. 10a c.f. b). The initial concern that double night fishing targeted lots of undersized lobsters and results in increased handling and release of lobsters is not supported by this research.

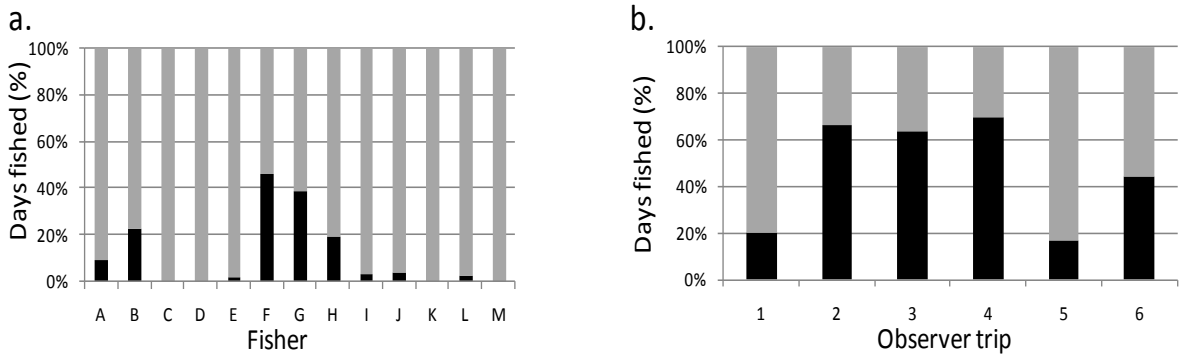


Figure 9: Percentage of fishing days where a double night fishing event was completed for a. all depth logger shots by fisher, b. each observer trip. Black bars: days with a double night fishing event, grey bars: days without double night fishing.

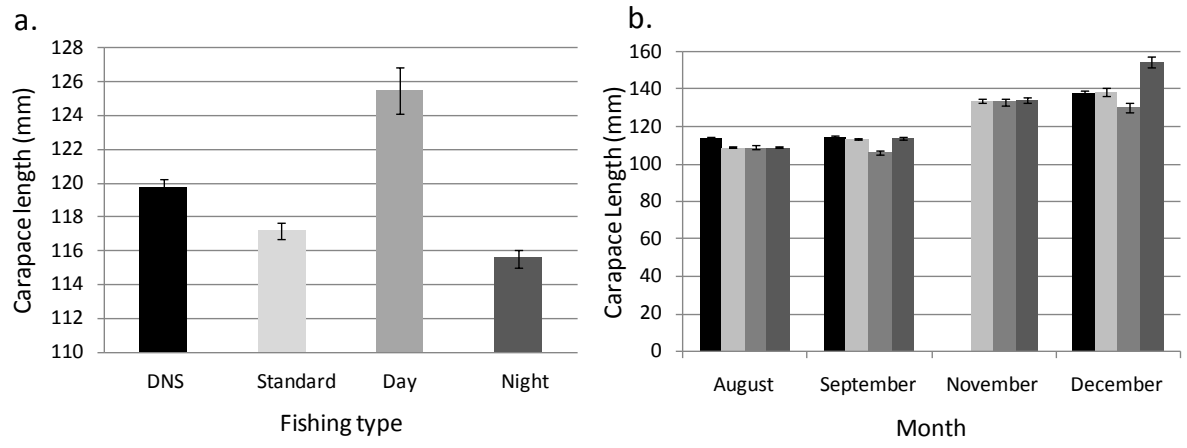


Figure 10: Carapace length (mean ±se) of lobsters landed by different fishing types. a. for all observer trips, b. by month. DNS, Standard fishing, Day, night

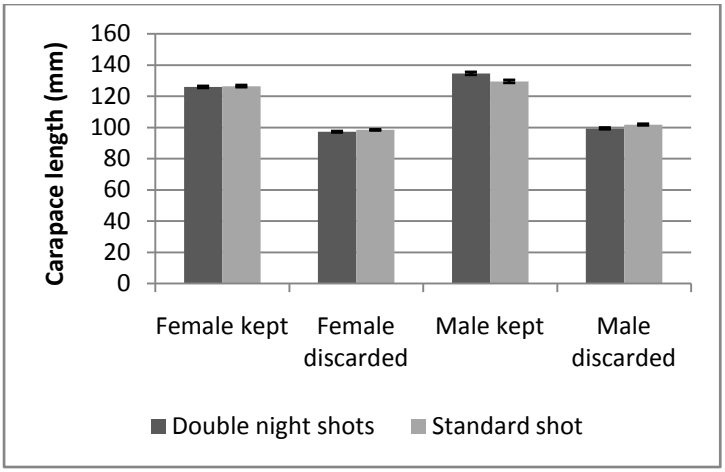


Figure 11. Size (mean CL ± se) of discarded and kept lobsters measured on observer trips.

The size of discarded lobsters was the same for double night fishing as it was for standard fishing. At the outset of this project there was a concern that fishing through the night led to an increased capture, handling and discard of smaller lobsters, particularly females. There was no indication that double night fishing was biased towards the capture and discarding of smaller lobsters (Fig. 11).

By-catch species diversity and abundance were the same regardless of fishing type (Fig. 12a, b), however lobster mortality due to octopus in pots were lower in double night fishing (Fig.13). Many fishers have reported that they use shorter soak time and double night fishing to reduce the number of octopus mortalities in their pots.

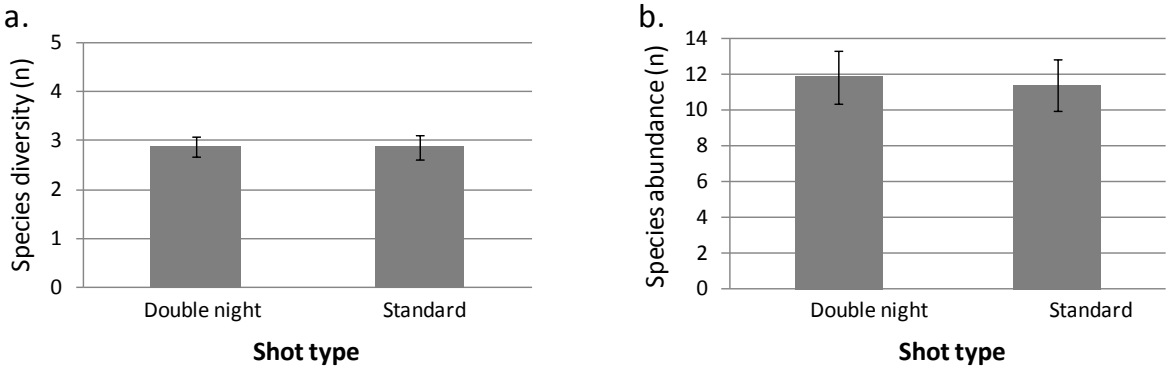


Figure 12: Bycatch (mean ± se) from double night and standard shots measured on observer trips the average a. Species diversity and b. Species abundance.

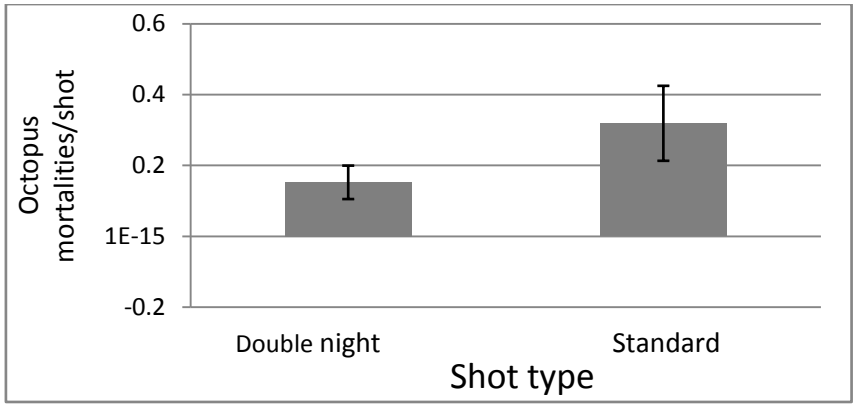


Figure 13: Number of lobsters killed by octopus within the pots (mean/pot ±se) from double night and standard shots measured on observer trips.

Assess whether capture increases limb loss and loss of limbs influences growth

The rate of injury and discards between double night and standard fishing trips was compared using data from observer trips. The injury rate for both types of shots was similar and occurred in less than 0.2 lobsters per pot ($F_{1,98}$=0.075, p=0.78). The discard rate was lower for double night fishing than for standard fishing trips ($F_{1,98}$=4.46, p=<0.05, Fig.14a).

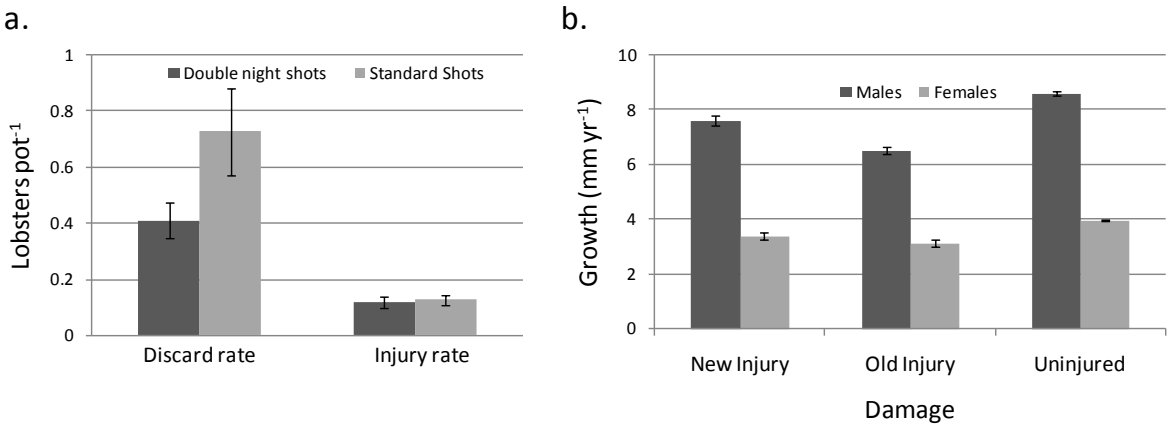


Figure 14: a. Rate of injury and discard of lobsters (mean ± se) per pot, b. annual growth rate of injured and uninjured lobsters, from double night and standard shots measured on observer trips

Long-term tagging data from CRAYBASE was used to assess the impact of injuries on the growth of rock lobsters. There were a total of 27,160 lobsters in the analysis. Of the 15,079 male lobsters, 1,487 had an old injury, 924 suffered a new injury and 2,277 had either type of injury. Of the 12,081 female lobsters, 924 had an old injury, 849 suffered a new injury and 1,670 had either type of injury. Injuries were limb or antennae loss.

Growth rate was reduced in both male and female lobsters that were injured through fishing handling and capture (males, $F_{1,15063} = 22.64$, $p < 0.001$, females $F_{1,12065} = 24.59$, $p < 0.001$, Fig. 14b). These results suggest some impact on the annual growth of lobsters from injuries caused by fishing, but as double night fishing did not increase the amount of damage to lobsters, then it is no more likely to reduce growth rates through injury and discards than standard fishing.

7.3. Assess the cost-effectiveness of double night fishing

Double night fishing resulted in no detectable change in catch rate and a slight increase in the number of shots per day and consequently the number of shots per trip. These changes were sufficiently small that even wide scale adoption of double night fishing will not substantially change the temporal or spatial composition of the Tasmanian rock lobster catch. The main exception to this (which has not been examined in this study) is if fishers change their fishing grounds in order to double night fish.

Due to the limited effect on the dynamics of the rock lobster fishery, a study of the effect of double night fishing using the Tasmanian bio-economic rock lobster model was not carried out. This study would have shown limited/no effect.

On average, fishers who double night fished carried out 0.16 additional shots per day (1.65 instead of 1.49). Consequently the daily catch rate for double night fishers is 11% higher. This clearly has positive economic implications for fishers as the same catch can be caught in fewer fishing days. We now consider this in more detail (Table 1).

The costs per potlift and vessel (Table 1) are taken from the SA 2009/10 survey and are thus more recent than surveys from Tasmania. Fishing operations in SA clearly differ from Tasmanian operations but this provides a general guide.

Table 1. Costs of lobster fishing split by variable and fixed costs

	Variable cost / Potlift	Fixed cost / vessel	Fleet fixed cost
Labour as fixed cost	$ 8.07	$ 224,007	$ 51,521,610
Labour as variable cost	$ 19.54	$ 94,115	$ 21,646,450

The first row considers the situation where labour is treated as a fixed cost, the second row where labour is treated as a variable cost. This distinction is important as it is unclear whether double night fishing will incur additional labour costs (i.e. it should be treated as a variable cost) or if fishers will work harder (in which case it should be treated as a fixed cost). For each vessel that begins double night fishing (to the extent that vessels in this study

double night fished) a fleet wide increase in profitability of between $24,640 (11% of 224,007) and $10,353 (11% of $94,115) would be obtained (depending on the additional labour costs required for double night fishing). This gain is obtained as the vessel can take a greater catch in fewer days, and consequently for every 9 vessels that take up double night fishing, the fishing fleet can be reduced in number by one vessel, thereby saving the fixed costs attributed to that vessel.

Similarly, the maximum gain obtainable across the fleet (if all vessels commenced double night fishing) is between $2.38million and $5.67million.

These values are maximum values and are unlikely to be fully realised in practice as vessels are unlikely to switch to double night fishing practices for every single trip.

7.4. Develop management strategy evaluations based on the outcomes of the project.

As there is currently no evidence that the fishing practice called double night fishing is widespread in the fishery or is responsible for significant increased catch rates, there is little value in a management strategy evaluation.

There is also no evidence that double night fishing influences catch rates or biomass, so our annual stock assessment model should be adequate to record any changes in the fishery. We do recommend that monitoring of the practice of double night fishing continues to assess whether in the future it is responsible for any increase in effort or catch rate that would result in a decline in inshore biomass. To this end, the log books would need to be changed to allow for the adequate recording of two shots in a single night.

At the outset of this project there was a call to ban the practice of double night fishing. To respond directly to this we have listed a number of options for legislation in the case that double night fishing was to be banned.

OPTIONS FOR LEGISLATION (from most to least prohibitive)

1. Prohibit two (2) Night Shots during the same Night whereby the *majority* of soak time for the two (2) shots has occurred during the Night

   (NOTE: this means that the 1st set can occur during the Day and the 2nd pull can occur during the Day but the majority of soak time for both shots has occurred during the Night)

2. Prohibit two (2) Shots occur during the same Night whereby both shots have been set and pulled *within* the Night period

3. Prohibit the *setting* of pots during the Night for a second (2^{nd}) time

4. Prohibit the setting and pulling of pots *between 9/10pm and 4am*
5. Prohibit Night Fishing/Double Night Fishing practices *in specified areas* (spatial management approach).
6. Establish a *Legal Minimum Soak Time* (E.g. pots must be soaked for 7 hours or more.)

If research on changing fishing practices in the SRL fishery is considered a priority then it is recommended that the requirements in the logbook for fishers to record 'shot type' and 'date of month' are removed and fishers instead record the time and date of first pot set and time and date of first pot hauled in two separate columns. This would remove the errors surrounding estimates of day and night hours a pot is underwater and the ambiguity in the recording of 'date of month' as the time of set or haul. 'Shot type' can be later determined using sunrise/sunset times and total soak hours. We also recommended that the logbook no longer allows fishers to combine shots across a given calendar day by simply reporting double the number of pots. It prohibits the matching of other sources of data such as observer records with logbook records and in some cases the two shots could be different 'shot types' (day or night) which is a misrepresentation. It also prevents researchers in the future from examining CPUE based on shot rather than pot. These amendments would enable an accurate assessment of the extent of double night fishing in the SRL fishery without depth logger or observer data.

8 BENEFITS

The main benefit to arise from this study is to alleviate the concern of the commercial fishery, the CFAC and TRFLA that double night fishing is the source of declines in the fishery. This refocuses efforts to manage the decline in the stock using spatial management options and implementing a constraining TACC.

In the application for this project we noted that any changes to fishing practices which bolster inshore stocks will also benefit the recreational and indigenous sectors as they predominantly fish inshore. As we are not recommending any changes to fishing practices as a result of this study we do not envisage any direct changes to the stocks which will increase or decrease the benefit to these groups.

9 FURTHER DEVELOPMENTS

Activities and other steps that may be undertaken to further develop the results of this research include a modification of the logbooks to record fishing activity at a finer scale and allow and assessment of changes in fishing practices. IMAS researchers are currently increasing the lobster tagging program to increase the number of tag and recaptures to

improve the growth and biomass estimates of inshore stocks. This will be used in the future to divide the inshore component of the stock assessment model to above and below 30m.

The data from this project was from four sources: 1. DPIPWE logbook database (ICE), 2. Data loggers, 3. Observers on lobster boats, and 4. Lobster growth data from Craybase, IMAS's long-term rock lobster database. The ICE database (1) is maintained by DPIPWE. The data from the data loggers (2) and observers (3) are stored in databases managed by IMAS Fisheries division. Craybase database (4) is maintained by IMAS Fisheries division.

10 PLANNED OUTCOMES

1. Introductory story in Fishing Today; led to fisher participation in data logger activity and offering vessels for observer work.
2. Presentation and report to CFAC 53 on definition of double night fishing and logbook structure; led to a framework for a change in the format of the compulsory DPIPWE logbooks to enable fine-scale effort reporting and therefore changes in effort to be more appropriately analysed. This will permit double night fishing and other effort changes to be monitored as part of the annual stock assessment.
3. Final report; provides tools and guidance for the future for a finer evaluation of the stock, an overview of the stock and double night fishing practices so that CFAC and DPIPWE can assess whether limiting or prohibiting double night fishing would result in different future biomass and CPUE estimates of inshore component of the stock, guidelines for defining double-night fishing and options for legislation for use in any future management action and delivered a CFAC and CRAG priority for assessing the impacts of double-night fishing.
4. The modified stock assessment model will enable future changes in the stock in different areas to be more easily detected. This modified model will provide the basis for future finer scale assessments once there is more detailed biological information.

This project has been communicated to the CFAC verbally on a number of occasions. There was a written report at CFAC 53 in March 2011 and through the industry magazine Fishing Today. A final summary has been drafted for Fishing Today and will be published in August 2012.

11 CONCLUSION

Double night fishing is not the primary cause of declines in the inshore stock of southern rock lobster. While we not able to directly assess the extent of the declines by further dividing the stock assessment model above and below 30 m (objective 1), we were able to determine that catch rates have been decreasing in both deep and shallow water at similar rates throughout most of the state. Fishers were concerned that an increase in multiple night

shots was masking real trends in catch rate data. To address this concern an analysis of catch rates restricted to day shots only was conducted. This analysis showed that overall catch rates declined by 13% state wide, and catch rates for day shots declined by 19% statewide.

The effort in double night fishing was adequately recorded in the logbooks and therefore captured in the current stock assessment and estimates of CPUE (objective 2). If research on changing fishing practices in the SRL fishery is considered a priority then we recommend that the requirements in the logbook for fishers to record 'shot type' and 'date of month' are removed and fishers instead record the time and date of first pot set and time and date of first pot hauled in two separate columns. Only 23% (3 out of 13) of fishers who identified as double night fishers undertook double night fishing on greater than 20% of their total days fished, suggesting that of the fishers sampled, double night fishing was not a substantial part of their fishing practice in the time period sampled. Of those that did conduct double night fishing trips, effort (number of shots per day) was slightly higher. There was no difference however in CPUE by shot. The size and number of discarded lobster and the rate of injuries were the same in double night fishing and standard fishing. The average size of lobsters was slightly larger in double night fishing although this size difference was much smaller than the monthly variation in sizes in any fishing practice. Growth rate was reduced in both male and female lobsters that were injured through fishing handling and capture but as double night fishing did not increase the amount of damage to lobsters then it is no more likely to reduce growth rates through injury and discards than standard fishing. There were no differences in by-catch composition between double night shots and standard shots. Lobster mortality due to octopus predation in pots was reduced with shorter soak time in double night fishing, and efficiency of fishing was increased.

Double night fishing is a cost-effective practice as it increases the efficiency of the fishery (objective 3). Under a TACC, increasing effort and reducing the costs of fishing had positive outcomes for the fishery, with an estimated increased in profitability per boat undertaking double night fishing of between $10 and 25K per year.

There was not a management strategy evaluation (objective 4) as at current levels of double night fishing our annual stock assessment model should be adequate to record any changes in the fishery. We do recommend that monitoring the practice of double night fishing continues to monitor future impacts on effort or catch rate that would result in a decline in inshore biomass.

12 REFERENCES

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Lyle JM, Tracey SR (2010) Tasmanian recreational rock lobster and abalone fisheries 2008-09 fishing season. Tasmanian Aquaculture and Fisheries Institute Report,

13 APPENDIX

Appendix 1 Staff

We thank the following staff involved in this project:

IMAS FAC: Gary Carlos, Tim Emery, Caleb Gardner, Bridget Green, Klaas Hartmann,

Sophie Hall-Apsland, Emily Ogier, Scott Mason, Chris McKinley

DPIPWE: James Parkinson and Hilary Revill,

TRFLA: John Sansom, Rodney Treloggen

The Crustacean Fishery Advisory Council

Appendix 2 Intellectual property

The research is for the public domain. The report is intended for wide dissemination and promotion.

Australian Government

Fisheries Research and Development Corporation