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Western Rock Lobster International Stock Assessment and Modelling Workshop Report

20 to 24 May 2010

Western Australian Department of Fisheries

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Department of **Fisheries**

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Executive Summary

An independent international review workshop was held between 20 and 24 May 2010, as part of the ongoing development of the western rock lobster stock assessment model and to respond to the relevant conditions set by the Marine Stewardship Council's (MSC) auditors at the November 2009 annual surveillance.

Main Objectives of the Workshop

- Review the stock assessment model and make any recommendations that would improve its robustness.
- Review the 2009 stock assessment.
- Review the current understanding and measurement of the rock lobster breeding stock.
- Review the proposed Harvest Strategy and Decision Rules.
- Assess the progress made to meet the conditions set by the MSC's auditors.

Summary of Review Panel's Major Findings and Recommendations

- The length, sex and spatially-structured population dynamics model being developed by the Department of Fisheries (DoF), is an appropriate basis for conducting stock assessments and providing management advice for the Western Rock Lobster Fishery.
- The spatial and temporal structure of the original ITE stock assessment model[1] was very complicated (to meet ITE management needs) and effort should be undertaken to reduce its dimensionality.
- Insufficient diagnostic statistics were available to fully evaluate the robustness of the model at the time of the workshop.
- Not all available data were used in the model and a number of parameters were estimated outside of the model. More parameters need to be estimated within the model using as many data sources as possible.
- The new ITQ model that was developed during the workshop should be used as the basis for all future development.
- In relation to the questions posed by the MSC auditors, some issues relating to uncertainty have been addressed in the new ITQ model. The report contains recommendations to ensure that other sources of uncertainty can be included more appropriately in future assessments.
- The structure of the decision rules framework is consistent with world's best practice. However, the specific decision rules need to be modified to reflect the move to an output (ITQ) based management system.
- A number of other prioritized technical recommendations were made by the Panel, including refining the new ITQ model developed during the workshop and developing a comprehensive set of diagnostics and sensitivity runs.

[1] This report refers to two assessment models. The model that was provided to the Review Panel before the workshop is referred to as the original ITE (individual transferable effort) model, whereas the modified version provided to DoF by the Review Panel at the end of the workshop is referred to as the "new ITQ (individual transferable quota) model".

- A Research Assessment Group should be established to facilitate ongoing development and testing of the stock assessment.
- A Management Strategy Evaluation framework should be developed to test alternative management arrangements.

Action Plan to progress Review Panel's recommendations

An Action Plan has been developed to progress the Review Panel's recommendations. Many of the short term priorities have already been completed and the others are being progressed. Details are provided at Appendix 11.

Progress to meet MSC conditions

All of the conditions set by the MSC's auditors at the November 2009 surveillance related to stock assessment issues have either been completed, or it is anticipated they will be by the time of the November 2010 annual surveillance. The only outstanding conditions that need to be resolved are those related to the Harvest Strategy and Decision Rules. This will have to be significantly reworked to reflect the change from the ITE (effort) based management system to the ITQ (catch) management system, which will occur at the start of the 2010/11 season. A report on the progress to meet the MSC conditions is provided at Appendix 12.

Comparison of outputs from the original ITE model and the new ITQ model

A preliminary comparison was made of the egg production (spawning stock abundance) outputs from the original ITE (effort based) and new ITQ (catch based) model that was developed at the workshop. Due to the time available, the comparison has only been made for Zone C. The comparison shows that the median estimates of egg production produced by both models were similar and therefore the recent management advice regarding the current status and predicted status of the breeding stock would not have been materially different if it had been based on the new ITQ model (see figures below). This indicates that the current assessment of stock sustainability for that zone was robust. Given that Zone C is the zone most affected by the very low puerulus settlements, it implies that the current assessments of stock sustainability for the other two zones of the fishery (Zones A and B) would also be robust.

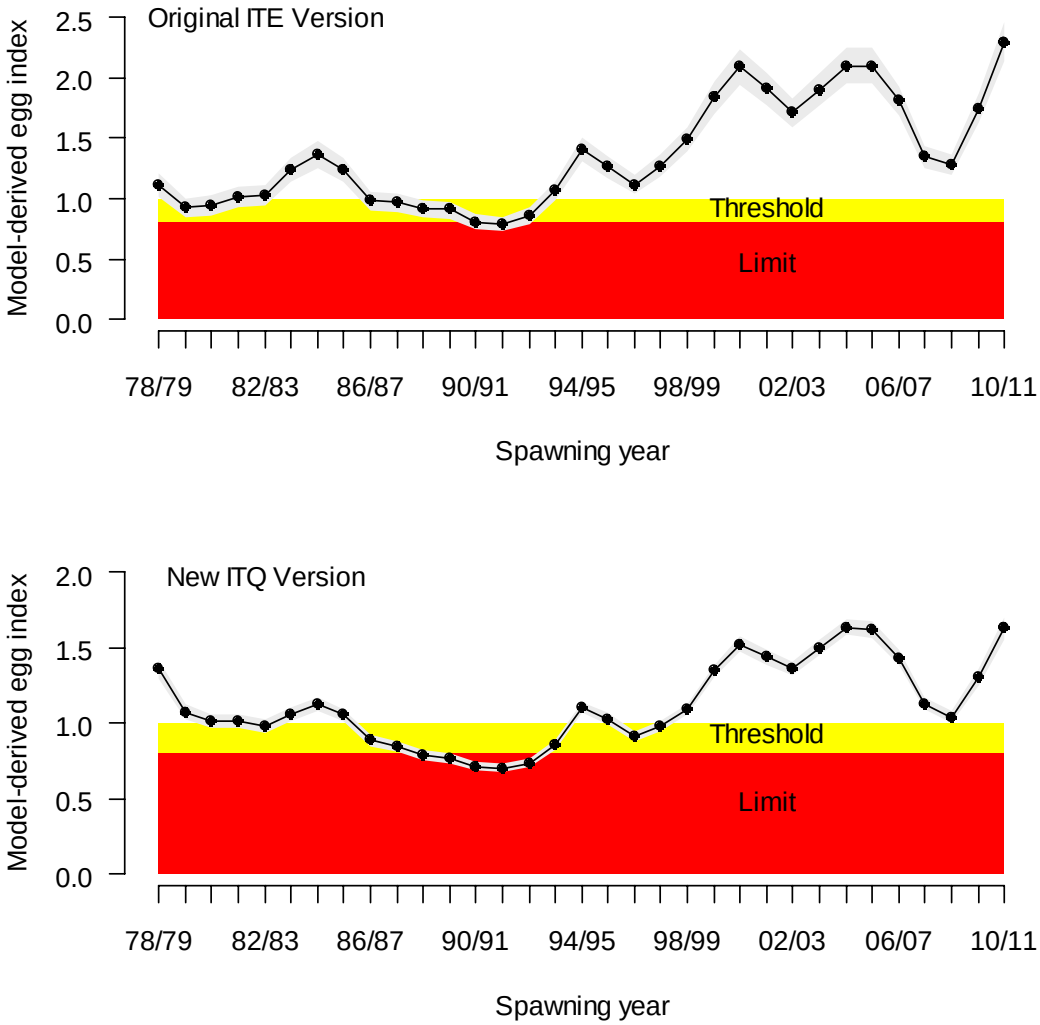


Figure 1. Estimates of egg production in Zone C of the Western Rock Lobster (WRL) fishery based on the original ITE version and the new ITQ version of the WRL Stock Assessment model. The black lines represent the median estimate of egg production, the grey polygon the 50% confidence region, the yellow rectangle the threshold region and the red rectangle the limit region.

Introduction

Background

The workshop was held at the Western Australian Fisheries and Marine Research Laboratories in Hillarys from the 20th – 24th May 2010, and included international, national and local reviewers. The Review Panel (henceforth referred to as the Panel) was headed by Prof Andre Punt (University of Washington, U.S.A.), and included Dr Cathy Dichmont (Commonwealth Scientific and Industrial Research Organisation), and Assoc. Prof Norman Hall (Murdoch University). Klass Hartmann (Tasmanian Aquaculture and Fisheries Institute, University of Tasmania) also participated in the review, though not as a formal member of the Panel.

This was the second international review of the western rock lobster stock assessment and modelling; the first took place in 2007 (Department of Fisheries 2008).

The Panel was given three primary objectives (Appendix 1):

- *Review the stock assessment model and make recommendations to enhance it. This will include an assessment of the progress made to meet the conditions set by the Marine Stewardship Council's auditors.*
- *Review the 2009 stock assessment. This will include an assessment of the progress made to meet the conditions set by the Marine Stewardship Council's auditors.*
- *Review the current understanding and measurement of the rock lobster breeding stock.*

There were also three secondary objectives:

- *Review the proposed Harvest Strategy and Decision Rules.*
- *Review factors that may be contributing to low puerulus settlement (e.g. source-sink, breeding stock, migration, environmental factors) and management implications.*
- *Help develop the framework for the bio-economic model that is to be developed and make recommendations on how to integrate it with the stock assessment model.*

Workshop procedure

The workshop was a technical workshop designed to assess the progress of the integrated rock lobster stock assessment model. The format of the workshop included providing a set of documents to the reviewers (Appendices 2, and 3), additional model information and diagnostics (Appendix 4), a series of presentations by Department of Fisheries (DoF) staff with stakeholders present (Appendix 5), informal discussions between reviewers and DoF staff, a presentation of the Panel's recommendations (Appendix 6) and the Panel's written report (Appendix 7).

Stakeholders attended the DoF presentations on Wednesday 20 May, Thursday 21 May (am only) and the Panel's presentation of recommendations on Monday 24 May (pm) (Appendix 8).

Information Provided or Presented

A series of documents were provided to the Panel prior to the workshop including, an Action Plan for MSC Principle 1 (Appendix 2), a list of web links to other pertinent information (Appendix 3) and additional information and diagnostics for the stock assessment model (Appendix 4).

Summaries of the DoF presentations are provided below with the PowerPoint presentations provided in Appendix 5. Comments on specific issues raised by either the Panel or stakeholders during the presentations were noted and have been combined into general issue categories. Questions for the purpose of clarification have not been included.

Welcome

Rick Fletcher

DoF welcomed the review team and gave the audience a brief summary of their expertise and experience in the area of fisheries stock assessment. The purpose of the review was then outlined, along with a description of its background, both in the context of MSC and also the model's development since the first stock assessment review in 2007 (Department of Fisheries 2008). The audience were also informed of the significant management changes that had occurred, and were still occurring, in the fishery and the intense level of research activity and provision of advice that was associated with this. It was highlighted that the model needed to be reviewed now to ensure it would be able to cope with the new quota management arrangements. It was pointed out that a set of questions had been developed that would be provided to the Panel to assist in the review processes (see section on *Specific Questions for Reviewers* below).

Comments; The Panel was keen to clearly establish the aims of the workshop and the degree of interactivity there would be between the reviewers and DoF staff. Panel members also highlighted some of the changes that should be made to the model, which could be completed during the workshop and the detail in which they would be reported.

Objectives of the Workshop

Rhys Brown

This presentation re-iterated a number of points made in Dr Fletcher's welcoming address. It highlighted the technical nature of the review and the background and timing of the model's development and assessments. The format of the workshop was also outlined including the objectives that were to be addressed and the timelines for reporting (Appendix 1).

Comments: A member from industry asked the Panel for its thoughts as to the potential error margin (uncertainty) around predictions of catch into the future and if these could be reduced through the model. The degree of uncertainty was explained as being the result of the lack of data on the effects of very low puerulus settlement on the recruitment – catch relationship, as recent settlements were below historic bounds.

Biology and Breeding Stock

Simon de Lestang

This presentation covered general aspects of the fishery – how it operated, a summary on the current management arrangements and the life cycle of *Panulirus Cygnus*, which focused on the post settlement to breeding stock portion of the lobster's biology. It also included tagging data showing western and northern migration of lobsters from coastal tagging sites and the possible effects of currents on the migration. The other major issue covered was the different types of breeding stock indices and how they were derived (including what adjustments are made to them). Size at maturity (SAM) was shown to be decreasing over time, while fishing efficiency was demonstrated to have been increasing. The impacts of SAM on the Independent Breeding Stock Index (BSI) and Dependant BSI, and of fishing efficiency on the Dependant BSI were also illustrated, along with environmental correlates. Predictions of BSI from the stock assessment model were shown to exhibit similar trends to the empirical BSI indices.

Comments; There was a wide variety of comments and questions, which have been grouped into the broad areas.

Tagging: Comments were made by the Panel regarding how migration was handled in the model, noting that there is no explanation as to how the numbers of rock lobsters migrating between cells in the model were derived. This led to a discussion on how the tagging data could be incorporated into the model to allow proportions to be estimated.

SAM: Some members of industry were concerned about the effects on egg production if larger females were being removed from the Abrolhos Islands (and other areas) and replaced by smaller less fecund females. They questioned whether this was being addressed in the model. It was explained that fecundity and double breeding were both size dependent and both were incorporated in the model. The Panel asked if a similar decline in SAM was noted for males. It was explained that this was only available from two point estimates, but it did show a decline similar to that of the females.

Fishing Efficiency: The Panel noted that there wasn't sufficient information in the stock assessment document pertaining to fishing efficiency data, i.e. how it was analysed and what went into the stock assessment model. Industry members commented that they considered the fishing efficiency estimates used in the model to be too low, i.e. that they were consistently underestimated by researchers.

Independent BSI: A number of issues were raised by the Panel regarding model design and the way the Independent Breeding Stock Survey (IBSS) data was inputted. The issues related to spatial division within the model and how the areas were chosen. The large number of divisions within the model may result in a lack of sufficient data in certain regions, which would result in unwanted "noise". The spatial complexity of the model had been identified by DoF as an issue and it was suggested it could be simplified by combing some adjacent regions that contained similar, little or no data. Another issue was that all data sources were not being used within the assessment model. It was noted that the IBSS data should be brought into the model, which would allow tuning of the model to IBSS in a spatial sense.

Industry concerns were that IBSS locations that were provided to DoF in the early 1990s were areas providing good catches of ovigerous female and may not be representative of the areas further offshore where they believed there were important spawning stocks, which had been more heavily exploited over the past decade.

Therefore the IBSS may not represent the true state of the total breeding stock, i.e. the IBSS estimates could be overestimating the actual breeding stock abundance.

Dependent BSI: The Panel again identified that it was difficult to identify where the data from the commercial catch monitoring program (which is used to generate the Dependent BSI), was used in the parameter estimations in the model. There was concern that the same data was being used in multiple places.

The Panel's other main issue pertained to sampling conducted as part of the commercial catch monitoring. While over 100 boats were sampled each year, it may not represent the effective sample size, as results from one boat could be confounded due to the nature of fishing activities and the size of each sample measured. There was considerable discussion of a statistical nature around this point and the Panel suggested a test which could be run to examine the impact of this issue.

It was recommended that a list be kept of alternative hypotheses that are generated, so that they could be used as scenarios for the model to run sensitivity analyses against.

Model BSI: The Panel queried the confidence limits (measure of uncertainty) around the Model BSI outputs with debate as to whether they were confidence or probability limits. It was noted that they could be quite similar but it was something that should be checked.

Model Description

Peter Stephenson

This presentation gave an overview of the data inputs and the important features of model structure, the parameters estimated, the form of the components of the objective function, and the outputs.

Comments: Throughout the presentation, there were a number of technical discussions regarding formulae, data transformations, etc. The major issues are discussed below.

Initial comments made by the Panel related to the long processing time to run the model. There was also discussion on some immediate changes that should be made to the method of the calculation of the initial conditions, the transformation of the catch data in the log-likelihood function, and the method of introducing the variability in data inputs such as natural mortality and sexual maturity.

Modifications and changes discussed included:

1. Extensive re-writing of parts of the programme code to make it run more efficiently.
2. Changing the way in which the variability in natural mortality and sexual maturity schedules are incorporated in the model.
3. Changing the catch transformation in the objective function.
4. Reducing the model complexity by reducing the number of areas and time-steps.
5. Changing the weighting of the length composition likelihood function.
6. An improved method of introducing variability in the projections.

7. A sensitivity analysis and retrospective analysis should be done routinely and the results made readily available for management and assessment meetings.
8. The calculation of efficiency increases were of concern and it was suggested that this area should be investigated. A more detailed description of the historic efficiency increases was also required.
9. The large amount of processing time required for the 50 length bins in the model was discussed. DoF staff explained that this was done so that the impact of a large variety of management changes could be investigated. The Panel suggested that given the level of uncertainty in the outputs, it was likely that the stock assessment model would not be informative in deciding between fine scale management changes, for example, changing the escape gap from 54 to 55 mm. If the fine scale management requirements could be ignored, it would provide scope for reducing the number of length bins and hence significantly increasing the speed of the model. It was agreed that this should be done.
10. The MSC requirement that IBSS data be incorporated in to the model had not yet been implemented. The Panel suggested how this could be achieved and requested the necessary data so that it could be done.
11. There was also discussion about text editors, equation writing software, computer memory upgrades, 64 bit processing, and model version control.

Model structure in terms of a potential "fleet" approach was discussed. This is where one larger area is fished by different fleets with different selectivity in different areas. The Panel saw that under an integrated fisheries management (IFM) framework, this approach could work well, as it would allow for the inclusion of the recreational fleet. However, after further discussion of the fishery's dynamics it was decided that it was not necessary to include it in the short to medium term.

There was considerable discussion regarding the multiple use of data within the model. This resulted from data being analysed outside the model and the parameters then being used in the assessment model. It was pointed out that this was not good practice, as it could artificially reduced the variability in the model outputs, especially when variables were bought in as fixed values. A good understanding of the variability was important given that management decisions are based on the model's best estimates.

Industry had concerns on the reliability of catch and effort statistics (CAES) data as a representation of the catch. DoF advised the Panel that CAES data are cross-referenced with returns from the processing factories, and in instances where there is disagreement, the CAES data is adjusted pro rata.

Specific Questions for Reviewer

Rick Fletcher

Dr Fletcher provided the Panel with a set of questions that DoF would like considered during the review (Appendix 9). It was stressed, however, that these were suggestions, and that they could be added to, deleted or modified as the Panel saw appropriate.

Comments: The Panel stated that they might not be able to address some of the specific questions, but would provide the methodology to assist in answering them. The Panel would restrict itself to non-policy related issues. There were questions pertaining to the report format, which concluded with the Panel and DoF reaching a consensus view that a single report was the preferred option.

There was a question from industry about moving management settings towards maximum economic yield (MEY) and whether there was a danger in moving away from the maximum sustainable yield (MSY) strategy. It was pointed out by DoF staff that MEY was generally a more conservative approach to protecting the breeding stock, however, the model would be used to provide advice on this issue.

Stock Assessment 2009/10

Simon de Lestang

This presentation dealt with the specific data inputs to the model and how they have been tracking over the last few years. It included information on the puerulus program, particularly the reduction in puerulus settlement over the last few years and the small mesh pot trial to sample young juveniles, which had been run on a large scale during the 2009/10 season. These two indications of fishery recruitment were then explained in terms of their impact on catch, effort, catch rates and egg production.

Comments: The Panel inquired whether the small mesh pot data was included in the assessment model. DoF responded that, as it was a relatively new data source it hadn't been included. Both the Panel and DoF staff agreed that its future inclusion would be very valuable.

Harvest Strategy and Decision Rules

Kevin Donohue

After outlining the intent of the harvest strategy and decision rules, Mr Donohue gave a brief history of the management of the fishery, focusing primarily on the last few seasons and the transition to quota management. The biological management objective for the fishery was then presented and the issues around total egg production, egg production per zone, the threshold levels for each zone, the five-year prediction framework (and the probability around it), were examined in detail. Data on each zone's modelled egg production relative to its threshold and limit values was then presented. The final part of the presentation dealt with the recent draft Harvest Strategy and Decision Rules paper (FMP 239; Department of Fisheries 2010), which covered the current biological objective and addressed the economic aspects of the fishery, i.e. an MEY target. This resulted in a series of questions to the Panel regarding various management options given the change from an individual transferable effort (ITE) management system to an individual transferable catch quota (ITQ) system.

Comments: With the move to an ITQ system, there were a lot of comments from both industry and the Panel regarding the impact of the management change.

Industry could see that a move to an ITQ system would result in a loss of a number of valuable long-term data sources. DoF staff assured stakeholders that the historic data sets were still important and would continue to be used in stock assessment although some recalibration may be required, as had occurred in the past when management

changes were made under input controls. In the future, however, there would be greater reliance on fishery independent sources of data and this was being factored in to research projects currently being developed to address ITQ issues. There was concern that the only independent measure of stock abundance for management purposes would be the IBSS, as not much reliance could be placed on CPUE abundance based estimates from an ITQ fishery. It was believed that too much reliance had be placed on CPUE in the South Australian quota managed lobster fishery and that this had been a contributing factor to the fishery's decline. Panel members responded by saying that under ITQ management the IBSS would become even more important to the assessment of the stock and it must be used. DoF staff noted that the IBSS wasn't originally designed to function as the sole measure of the breeding stock and that it would need to be expanded to serve this purpose. There were offers of industry assistance to help expand the IBSS into deepwater areas.

The Panel's comments focused on the potential spatial changes to the model, given the move to ITQ management. This was prompted by a discussion on the importance of egg production in different areas and the potential to look at this issue using model outputs and the IBSS. It was noted that egg production was unlikely to be homogenous in all zones. Shallow water egg production is significantly lower than deep water and new information from oceanographic modelling suggested all eggs may not be equal in terms of their importance to recruitment.

There was also discussion pertaining to the specifics of the decision rules and strategies. The Panel noted that it wouldn't comment on the threshold levels that had been chosen, as these were historically / policy derived figures rather than being derived from the science / model outputs and as such were considered outside its terms of reference. However, the Panel did make significant comments regarding the confidence levels around the predictions, as they are currently provided in the Harvest Strategy and Decision Rules document (Department of Fisheries 2010).

The Panel highlighted that incorporating uncertainty into the decision rules would be beneficial, but would be a challenge for the assessment team, as it was difficult to gain a best estimate as well as account for the variation around it. A lot of work had been done in the northern hemisphere regarding uncertainty in assessment models; there being a number of potential causes, including model author uncertainty with different, but valid assumptions being made by different modellers. It was suggested that with variation being incorporated into the decision rules, a definition of what was regarded as uncertainty should also be stipulated, as this could overcome potential litigation aspects. A comment was also made with regard to the nomenclature pertaining to probability and confidence limits and a technical discussion ensued, with the result that it was suggested that DoF stay with the terms used in the Harvest Strategy, as they are easily understood by stakeholders. However some analysis should be undertaken using a MCMC vs. Hessian asymptotic comparison to determine if the distributions of probabilities vs confidence limits were similar.

Another issue raised by the Panel concerned the recovery plans and the potential conflict between the short and long term aspects of the decision rules (Department of Fisheries 2010). DoF staff explained the rationale as to why there wasn't a specific recovery plan in place, but the Panel noted that this wasn't well described in the document. The Panel suggested running some scenarios in the model that would result in egg production falling below the threshold / limit levels to see how the rules and

recovery plans would cope. If there were strange outcomes, it could be the result of using the same data for short and long term management outcomes.

The use of the word "limit" in the harvest strategy was also questioned, as in most other jurisdictions it usually referred to the point at which a fishery was closed. It was explained that this wasn't the case for the use of the word in the rock lobster harvest strategy, and that a definition was provided in the document. The Panel noted that the DoF definition was consistent with the MSC's definition of recruitment limited, however, they believed that this definition might require further clarifiction.

The final discussion points revolved around the target values for the harvest rate, as they related to MEY. Because MEY used harvest rates (Department of Fisheries 2010), there was discussion as to the appropriate dataset on which to base MEY targets. The Panel noted that the MSC do not have a strict interpretation of what MEY should be based on. In the rock lobster's case either egg production or harvest rates would be applicable. The issue of vulnerable biomass was raised and how it should be dealt with, as it is this, not egg production, that is being fished. The Panel noted that the use of vulnerable biomass may, if incorrectly estimated, lead to localised depletion. Therefore having a relatively even harvest rate spread across the fishery was more precautionary and in line with MSC standards. It was concluded that the rationale for using egg production rather than the concept of vulnerable biomass should be clearly articulated and documented.

Environmental Effects on puerulus and migration

Nick Caputi and Simon de Lestang

The presentation focused on the current research dealing with the recent low puerulus settlements. The findings of the Low Puerulus Settlement Risk Assessment Workshop (Brown 2009) were outline with the major potential factors being either environmental change, low breeding stock (particularly at specific important locations), or a combination of the two. The 12 research projects examining these factors were outlined with particular emphasis on two projects involving the oceanographic larval modelling and statistical assessment of environmental and breeding stock effects.

The results to date from the oceanographic modelling project, along with the direction for the second phase of the project, were presented. Environmental effects on puerulus settlement were then discussed, including the potential influence of the Indian Ocean Dipole. Recent research looking at the environmental effects (primarily water temperature) on the breeding stock was explained. The implications of the reduction in migration levels to the deepwater areas north of the Abrolhos Islands was discussed and placed in the context of a possible management option to close the northern Abrolhos area.

Comments: Most of the Panel's questions initially concerned the parameters in the oceanographic model, e.g. how mortality was modelled and the variance around the parameter estimates. There was also a broader discussion of why egg release didn't appear to be timed around periods producing maximum larval survival.

The Panel's questions then focused on the environmental parameters that were used in the stock assessment model, i.e. which parameters were used in which estimates.

Most of industry's queries related to aspects of the stock assessment model, as opposed to the oceanographic model. They concerned issues such as biomass carry over from one season to the next, changes in selectivity due to escape gap changes, the extent of northerly migration and changes to catch rates expected to occur with the move to ITQ management. DoF staff and Panel members provided clarification on these points. A question raised the relationship between spawning distribution and puerulus. DoF staff informed industry that this was one of the areas that would be explored in the second phase of the oceanographic modelling project.

Summation

Rick Fletcher

Dr Fletcher provided a brief overview of the comments and issues that were raised throughout the presentations. This concluded the presentation phase of the review, with the Panel and relevant DoF staff remaining to work on specific aspects of the stock assessment model and the inputs used.

Workshop Planning

Cathy Dichmont

The Friday afternoon session began with the Panel meeting to discuss the way the remaining part of the day and weekend was to proceed. This resulted in a list of tasks to be completed, which were assigned to different members of the Panel and DoF staff. The Panel explained that DoF would receive two sets of model code at the end of the workshop, the first a slightly revised current model and the second, which contained more significant changes, would be compatible with quota (ITQ) management. DoF staff and Panel members then proceeded to complete their requisite tasks for the remainder of the day and over the weekend.

Review of Draft Report

Cathy Dichmont & Rick Fletcher

(Morning session Monday 24 May 2010)

A discussion was held between the Panel and DoF staff regarding the layout and final content of the draft review report the Panel had produced over the weekend. This was largely to ensure that that wording and definitions in the report would not be misinterpreted and cause confusion. For example the new model developed during the workshop was named the "ITQ model" to distinguish it from the original ITE based model and suggestions were made regarding the inclusion of extra clarifying text in some sections.

Review Panel Presentation

Cathy Dichmont

(Afternoon session Monday 24 May 2010)

After an initial explanation of the workshop process by Dr Fletcher, Dr Cathy Dichmont presented the Panel's major findings and recommendations to DoF staff and stakeholders. This section is not summarised, as the Panel's power point presentation (Appendix 6) and report (Appendix 7) are provided in full. There were, however, a number of comments made by stakeholders, which are covered below.

Industry members were concerned that there would be a 'jump' to using the new ITQ model that had been developed during the workshop and suggested that the original ITE and new ITQ models should be run in parallel for a period of time. Dr Dichmont stated that there would be a period of continuity testing between the two models, however, putting effort into updating the original ITE model or going back to it to address stock assessment and management issues would be very time consuming and not very rewarding. The new ITQ model provided the best option for moving forward.

Industry also questioned the potential bias of the models and were concerned that they may potentially be overly conservative, particularly regarding exploitable biomass in Zone C. They also asked if there were ways to eliminate such bias. Dr Dichmont responded that the bias would be reduced as much as possible by having parameters previously estimated outside the model, estimated within the model. This, combined with a management strategy evaluation (MSE), would ensure the robustness of the model outputs. The use of a MSE was also suggested as a way of assessing the need for additional field research and monitoring. Industry suggested the possibility of increased co-operative research to provide relevant data to help reduce uncertainty in model outputs.

The Panel explained that sensitivity analysis of the model would highlight areas where increased data collection could be advantageous and co-operation with fishers to obtain this data would be beneficial. It was also noted that through a MSE the benefits of additional research with regard the model outputs and the harvest strategy and decision rules could be determined. For example, the change in fishing practices that the move to ITQ management would inevitably produce, may require increased independent size structure and breeding stock survey work to reduce some of the uncertainty around the data.

The importance of the IBSS data was highlighted through the issue of quota setting. Industry was concerned with the predictability of stock "carry over" under ITQ and how this uncertainty could affect future projections of quota limits. The Panel noted that the IBSS data (or that obtained from an expanded independent monitoring program) should show if the model was not performing correctly, i.e. not reflecting what fishermen where seeing in their traps / on the fishing grounds. The Panel highlighted the need for the independent surveys to continue, as they were considered even more important under an ITQ than an ITE management system. Industry raised concern regarding the location of the current IBSS areas, as they believed that some of the major breeding stock areas (particularly in deep water) were not being covered. It was explained by the Panel and DoF staff, that due to the increased importance of independent breeding stock sampling, the programme would need to be expanded and industry members would be asked to help identify important breeding areas that should be monitored.

Target setting in a MEY context was discussed at length and the link between the stock assessment model and bio-economics was explained in more detail. The discussion then moved to why MEY was being considered when it wasn't a MSC requirement. The Panel explained that they were asked by DoF to examine the MEY concept for the fishery. Industry members were concerned with the potential use of MEY targets, given the current financial pressures the fishery was under. It was explained that the MEY concept was a target area rather than a specific value, which would provide more explicit direction for management compared to a breeding stock

threshold limit. Managing to a target area MEY should result in better sustainability and economic outcomes for the fishery.

Industry were concerned that over recent seasons the puerulus-environment model was not able to predict the reduced puerulus settlement. DoF staff explained that the relationship between known environmental factors and puerulus settlement had broken down and was no longer able to explain variations in settlement. This suggested that there was either an as yet unknown environmental factor affecting puerulus settlement, or a decline in some area(s) of the breeding stock that was causing the problem, or a combination of both. The Panel recommended investigating the potential for including a stock recruitment relationship in the model and continuing to investigate source-sink relationships (i.e. what breeding stock areas were most important in producing puerulus settlement).

The issue of weighting the different breeding stock areas to provide a weighted index of egg production was raised, e.g. giving greater weight to the northern breeding stock, particularly northern Abrolhos and Big Bank. The Panel was of the opinion that given the uncertainty surrounding the various contributions of the different breeding stock areas to the overall egg production and puerulus settlement, a more cautious unweighted approach should be maintained for the present, which should ensure adequate breeding stock throughout the fishery. This would need to be changed if the source-sink, or other research showed that some BS areas were more important in producing puerulus settlement.

An industry member stated that he believed, the science being presented showed that the fishery was on the "edge". There was a lot of concern in industry due to the unexplained low puerulus settlements, the management change to ITQ and the development of a new assessment model for the ITQ system. There was apprehension that due to the management and model changes there was potential to loose the historic continuity of the databases that had been critical for the assessment and management of the fishery in the past. This concern was recognised by the Panel and DoF staff, however, the Panel explained that the situation was not unique to the western rock lobster fishery. Other fisheries both in Australia and overseas had undergone similar changes and their experiences could be drawn on. A strategy for ongoing data collection and evaluation (including model evaluation) was being developed to ensure the best available stock assessment advice was provided to the fishery's managers. Panel members expressed the need for a close working and non-adversarial relationship between research and industry to assist during the challenging transition to an ITQ system.

The only other major issue raised was the incorporation of migration data into the model. The Panel had discuss this previously and decided that it wasn't feasible to incorporate it into the new ITQ model in the time frame available at the workshop. Industry members were disappointed by this decision, however, it was explained that the migration would be incorporated, as part of the ongoing development of the model. The MSC's auditors had also highlighted the migration issue as a task that needed to be completed.

Epilogue

This concluded the Western Rock Lobster International Stock Assessment and Modelling Review Workshop for 2010. The Panel presented a final report to the Department of Fisheries on the 27 May 2010 (Appendix 7). Modifications to the stock

assessment model, recommended by the Panel, have already begun. An initial comparison of the outputs on breeding stock levels from the original ITE model to the new ITQ model has also been undertaken (Appendix 10).

For completeness, the Action Plan to progress the Review Panel's recommendations and the progress made to meet the conditions set bey the MSC's auditors at the November 2009 surveillance are provided at Appendix 11 and 12 respectively.

References

Brown, R. 2009. *Western Rock Lobster Low Puerulus Settlement Risk Assessment:*

Draft Report For Public Comment: Workshop Held 1 And 2 April 2009 WA Fisheries and Marine Research Laboratories Hillarys. Fisheries Occasional Publication No. 71. Department of Fisheries, Perth, Western Australia

Department of Fisheries 2008. *Western Rock Lobster Stock Assessment and Harvest Strategy Workshop,16 – 20 July 2007 Western Australian Fisheries and Marine Research Laboratories.* Fisheries Occasional Publication No. 50. Department of Fisheries, Perth, Western Australia

Department of Fisheries 2010. *Western Rock Lobster Fishery Harvest Strategy and Decision Rules Framework Proposals: A Discussion Paper.* Fisheries Management Paper No. 239. Department of Fisheries, Perth, Western Australia

Appendix 1 – Workshop Objectives and Program

WESTERN ROCK LOBSTER
INTERNATIONAL STOCK ASSESSMENT AND MODELLING WORKSHOP
Thursday 20 to Monday 24 May 2010

Primary Objectives of the Workshop:

- Review the stock assessment model and make recommendations to enhance it. This will include an assessment of the progress made to meet the conditions set by the Marine Stewardship Council's auditors.
- Review the 2009 stock assessment. This will include an assessment of the progress made to meet the conditions set by the Marine Stewardship Council's auditors.
- Review the current understanding and measurement of the rock lobster breeding stock.

Secondary Objectives of the Workshop

- Review the proposed Harvest Strategy and Decision Rules.
- Review factors that may be contributing to low puerulus settlement (e.g. source-sink, breeding stock, migration, environmental factors) and management implications.
- Help develop the framework for the bio-economic model that is to be developed and make recommendations on how to integrate it with the stock assessment model.

Invitees:

Panel: International / national modelling experts:

- Prof Andre Punt (University of Washington USA) – lead reviewer
- Dr Cathy Dichmont (CSIRO)
- Assoc Prof Norman Hall (Murdoch University)

Fisheries Economist (Observer)

Dr Klaas Hartmann (Tasmanian Aquaculture and Fisheries Institute, University of Tasmania.)

Department of Fisheries modelling / stock assessment / statistics / biology experts:

- Dr Rick Fletcher
- Dr Nick Caputi
- Peter Stephenson
- Dr Simon de Lestang
- Adrian Thompson
- Dr Brent Wise
- Rhys Brown
- Dr Anthony Hart

PROGRAMME (summary)

Day 1 – Thursday 20 May 2010

9-12 Model discussions with Cathy, Norm, Klaas

12:00	Lunch	
1:00	Welcome	R Fletcher
1:15	Objectives of workshop	R Brown
1:30	Breeding stock	S de Lestang
2:00	Model description	P Stephenson/S de Lestang
3:00	Break	
3:30	Stock assessment 2009-2010	S de Lestang
4:00	Harvest strategy and decision rules	K Donohue
4:30	Environment effects on puerulus, migration	N Caputi/S de Lestang
5:00	Refreshments	

Day 2 – Friday 21 May 2010

- 2009 stock assessment review (one or two hours?) if not already done on Thursday.
- Modelling group[2] to work on model
- Late afternoon – bio-economic model discussions

Day 3 – Saturday 22 May 2010

- Modelling group / individuals to work on model

Day 4 – Sunday 23 May 2010

- Morning – report writing?
- Afternoon – social event (late lunch?) with room to talk shop informally.

Day 5 – Monday 24 May 2010

- Morning – assessment of the progress made to meet of Marine Stewardship Council auditors conditions:
    - model
    - 2009 stock assessment
    - Harvest Strategy and Decision Rules

- 3-5 pm – presentation and discussion of recommendations:
    - Welcome (R Fletcher)
    - Overview of process (R Brown)
    - Andre, Cathy and Norm:
        - breeding stock
        - stock assessment model
        - 2009 stock assessment
        - Harvest Strategy and Decision Rules
        - factors that may be contributing to the low puerulus settlement
        - bio-economic model
        - other issues

[2] Modelling group – Andre, Norm, Cathy, Peter, Simon and Nick

Appendix 2 – Action Plan for MSC Principle 1

MARINE STEWARDSHIP COUNCIL CERTIFICATION OF THE WESTERN ROCK LOBSTER FISHERY

Action Plan 2010 to Meet the Conditions Set by SCS's Auditors for Principle 1 – Stock Assessment

Background

In March 2000 an industry lead initiative resulted in the Western Australia Rock Lobster Fishery (WRLF) becoming the first fishery in the world to be certified by the Marine Stewardship Council (MSC). In December 2006 the WRLF was successfully re-certified by Scientific Certification Systems (SCS) for a further five years (i.e. until Nov 2011). The MSC certification process is considered to be the most rigorous and comprehensive independent fisheries assessment in the world and the WRLF has demonstrated strong leadership in its willingness to embrace this rigorous and transparent process that covers stock assessment, effects of fishing on the ecology and management practices and governance. Many of the certification conditions set by the SCS/MSC are also requirements for export approval under the Commonwealth Government's *Environment Protection & Biodiversity Conservation Act 1999* (*EPBC* Act – ecologically sustainable fisheries legislation).

The Western Rock Lobster Council (WRLC) is the Client for the certification of the western rock lobster fishery (WRLF) by the Marine Stewardship Council (MSC) and the cost is recouped from the commercial industry via a cost recovery process. The Department of Fisheries (DoF), as the management authority and major research provider, plays a crucial role in facilitating the certification process.

The MSC's independent certification body (CB), Scientific Certification Systems, undertook the annual audit of the fishery and a special audit of Principle 1 (P1) – Stock Assessment, in November 2009. The special P1 audit was conducted due to concern regarding the very low puerulus settlements that occurred in 2007/8, 2008/9 and more recently in 2009/10 and how they would impact on the breeding stock and hence the long term sustainability of the fishery. SCS set a number of conditions for ongoing certification under Principle 1, Principle 2 – Effects of Fishing and Principle 3 – Governance.

Following a meeting between the WRLC and DoF regarding the conditions set by SCS's auditors on Tuesday 10 February 2010, the draft Action Plan below was developed.

Full details, of SCS's November 2009 surveillance report can be found on the MSC's website at: http://www.msc.org/track-a-fishery/certified/south-atlantic-indian-ocean/western-australia-rock-lobster/reassessment-downloads-1

Set out of the Action Plan

The condition set by SCS is shown in yellow.
The initial Client response and action plan is shown in green.
A detailed and revised Client response is shown in pink. The Client is seeking some changes to timelines under Principle 1 due to: 1. Conflicts between the requirements of some of the conditions, and / or 2. To streamline the process and add greater efficiency to the workflow.

Principle 1 – Stock Assessment

Most of the conditions set for Principle 1 would have been done as part of the normal stock assessment and modelling review / development process. The stock assessment group appear to have most of them in-hand.

Condition 1.1.1.5 (2009): The client shall provide to the CB a report showing how current major uncertainties in BSS and IBSS indices, including changes in maturity and environmentally induced inter-annual changes in catchability, have been addressed. The report will include revised time series for estimates of breeding stock, including confidence bounds and the way that they reflect the uncertainties in the analyses. The report shall be reviewed as part of the international review of the stock assessment (see indicator 1.1.5.1) and the reviewed and agreed time series will then be used in the quantitative stock assessment. **Timeline:** Report to be provided to CB by March 2010 for subsequent review by international peer reviewer.

Condition 1.1.1.5 **Client Response and Action Plan**	**Timeline(s)**
The Senior Research Scientist (Stock Assessment) in charge of this area does not return from his overseas Churchill Fellowship until February 2010, therefore, depending on the amount of work involved, the timeframe for completion of the report may need to be extended to the end of March 2010. A progress report will be provided to the CB.	Progress report to be provided to the CB by 28 February 2010. Report to be completed and provided to the CB by no later than 31 March 2010.

Condition 1.1.1.5 **Actions and comments**	**Person(s) responsible**	**Timeline & comments**
Progress report to SCS **completed**.	Rhys Brown	**Completed** 16 Feb 10
Report showing how current major uncertainties in BSS and IBSS indices, including changes in maturity and environmentally induced inter-annual changes in catchability, have been	Simon de Lestang lead person. Report to be finalised by 23 April.	Report to be reviewed as part of 20 – 24 May 10 international workshop,

addressed. The report will include revised time series for estimates of breeding stock, including confidence bounds and the way that they reflect the uncertainties in the analyses. Timeline March 10. Report to be reviewed as part of the international review of the stock assessment (see indicator 1.1.5.1) and the reviewed and agreed time series will then be used in the quantitative stock assessment.		therefore an extension to 26 April is sought to bring this inline with 1.1.5.1 and the date that all the information will be provided to the participants of the See 1.1.5.1 and Attachment 1.

Condition 1.1.4.2 (2009): The Client shall provide the CB with clear evidence that the interim harvest strategy and decision rules applied for the 2009/10 fishing season, and intended to be applied for future management of the fishery, have been **formally endorsed by the Minister** and made publicly available. **Timeline:** To be completed by March 2010[0].		
Condition 1.1.4.2 **Client Response and Action Plan**		**Timeline(s)**
The harvest strategy discussion paper is progressing and should be released for a six to eight week public discussion period in early January 2010. After incorporating public comments where appropriate, the paper will be finalized. It is anticipated that the finalized report will be presented to the Minister for his approval by mid March 2010.		Update on the progress of the discussion paper to be provided by 15 Feb 2010. Anticipated date of approval by the Minister is the end of March 2010.
Condition 1.1.4.2 **Actions and comments**	**Person(s) responsible**	**Timeline & comments**
The Client shall provide the CB with clear evidence that the interim harvest strategy and decision rules (HSDR) applied for the 2009/10 fishing season, and intended to be applied for future management of the fishery, have been formally endorsed by the Minister and made publicly available. Timeline March 10. **Comment** The paper was behind schedule in being released for 6 weeks of public comment. There is also a requirement for the HSDR to be reviewed at the workshop that has been	Rhys	To meet the requirement to review the HSDR at the workshop on 20-24 May 10 (see program Attachment 1) and then for it to be endorsed by the Minister, an extension to the end of June 2010 is sought. The HSDR that goes to the 20-24 May workshop for review

organised for 20-24 May 10 (Attachment 1). Comments from the workshop will then need to be incorporated into the HSDR and it will then be finalised and sent to the Minister for formal endorsement. The HSDR will complete its public submission phase and comments received (including those of an independent international expert) will be incorporated by about late April. The international experts that will review it at the 20-24 May 2010 workshop will be sent a copy on 26 April 10, when all the other workshop documents are sent out.		will be sent to the CB on 26 April 2010, when all the docs are sent out to workshop participants.
Have the harvest strategy and decision rules reviewed by independent international experts during the public comment phase. **Comment 1** Arrange contracts for 1 or 2 international experts to the review and comment on the Decision Rules paper. To be completed by the end of the public comment period so their comments can be incorporated. **Comment 2** Arrange for DoF research / management expertise to review and comment on the Harvest Strategy Decision Rules paper as part of the public comment process.	Rhys	Late April 2010 to have public and international expert(s) comments incorporated into HSDR. 26 April send copy to 20-24 May workshop participants. Early June 2010 to have workshop reviewers' comments incorporated and end of June to have HSDR endorsed by Minister.

Condition 1.1.4.4 (2009):

Issue a clarification of what is intended by the elements in the harvest strategy that involve undertaking a review, such that there is confidence that this measure will not be used to delay appropriate management responses, but instead be used to determine the most effective form of management response, within reasonable time frames.

Timeline: To be completed by March 2010[0], as in 1.1.4.2.

Condition 1.1.4.4 **Client Response and Action Plan**	**Timeline(s)**
Clarification of what is intended by the elements in the harvest strategy that involve undertaking a review will be included in the Harvest Strategy	Clarification of the 'review' to be included in the Harvest Strategy discussion paper to

discussion paper. The 'review' will be used to determine the most effective form of management response, within a reasonable time frame(s).	be released for public comment in early January 2010.

Condition 1.1.4.4 **Actions and comments**	**Person(s) responsible**	**Timeline & comments**
Completed.		

<u>Condition 1.1.5.1 (2009):</u> *(This condition also applies to indicators 1.1.2.2, 1.1.5.2 & 1.1.5.5)*

Undertake an international peer review of the current (2009) stock assessment and work with the peer reviewer(s) to develop a robust assessment of the stock. Issues to be addressed include:

- Estimating depletion within the model by fitting to seasonal trends in catch rates
- Reintroducing breeding stock indices into the objective function (after the condition for indicator 1.1.1.5 is met)
- Estimating efficiency change within the assessment model
- Identifying key uncertainties in assumptions and data and undertaking appropriate sensitivity analyses

Issues to be considered include:

- Estimating the relationship between puerulus settlement and recruitment within the assessment model
- Incorporating size data into the assessment

The client shall than provide a report to SCS of the outcome of the review, including an updated 2009 quantitative stock assessment report, based on recommendations and findings of the review. Assuming a satisfactory resolution of the current uncertainties and problems in the assessment, the new assessment model would then be used as the basis for the 2010 assessment and for the provision of management advice for the 2010/11 fishing season.

Timeline: 8 July 2010

<u>Condition 1.1.5.1</u> **Client Response and Action Plan**	**Timeline(s)**
An international peer review of the current (2009) stock assessment will be undertaken. The peer reviewer(s) will help develop a robust assessment of the stock and address the issues listed above. A report of the outcome of the review will be provided to the CB and will include an updated 2009 quantitative stock assessment report, which will be based on recommendations and findings of the review.	An update on progress to meet this condition will be provide to the CB by mid May 2010. The Client will use

		its best endeavours to have the report completed by 8 July 2010.
Condition 1.1.5.1 **Actions and comments**	**Person(s) responsible**	**Timeline & comments**
Update report by mid May 10 – Completed This section of the action plan provides the update report to the CB on progress to meet this condition.	Rhys	**Completed –** This section of the Action Plan provides the update report.
Organise international workshop to peer review the current (2009) stock assessment and develop a robust assessment of the stock. **Organisation of workshop Completed** A workshop has been organised for 20 to 24 May 10, see Attachment 1 for program and list of participants.	Rhys to organise workshop.	A workshop for 20 to 24 May 10 has been organised. See program and participants at Attachment 1.
Modelling and stock assessment work as outlined above. The *Stock Assessment of the West Coast Rock Lobster Fishery (Draft)* at http://www.fish.wa.gov.au/docs/frr/frr180/index.php?0401 will be updated so that it can be disseminated to workshop participants on 26 April 10 (i.e. three weeks before the workshop).	Simon, Peter and Nick	**23 April 10** so it can be sent to workshop participants on 26 April 10.
Write the report of 20-24 May 10 international peer review workshop. Report to be in the hands of the CB by 8 July 10.	Jason Howe coordinator / writer	**1 July 2010** so it can be sent to the CB on 8 July 10.

Condition 1.1.5.2

Revised Rationale: While there is considerable exploration and analysis of uncertainties in data and parameters in the background information on the assessment (Caputi et al 2009), few of these are properly reflected in the quantitative assessment

(Stephenson and de Lestang 2009). The exception is uncertainty about future recruitment arising from the collapse in puerulus settlement, which is dealt with in the projections but does not (yet) impact on the assessment of current resource (breeding stock) status. As noted elsewhere in this report, key uncertainties that should be dealt with include changes in efficiency of effort, and changes in maturity and catchability affecting breeding stock indices. The confidence bounds presented in the assessment report do not adequately reflect (underestimate) the true level of uncertainty in the assessment. Overall, the fishery meets the 60 scoring guidepost, and the second element of the 80 scoring guidepost (to the extent that uncertainty about puerulus settlement is dealt with).

Condition 1.1.5.1 (2009) above should address the uncertainty in the assessment.

Condition 1.1.5.2 **Client Response and Action Plan**	**Timeline(s)**
See response to 1.1.1.5 and 1.1.5.1	31 March 2010.

Condition 1.1.5.2 **Actions and comments**	**Person(s) responsible**	**Timeline & comments**
Uncertainty about future recruitment arising from the collapse in puerulus settlement is dealt with in the projections, but does not (yet) impact on the assessment of current resource (breeding stock) status. As noted elsewhere in this report, key uncertainties that should be dealt with include changes in efficiency of effort, and changes in maturity and catchability affecting breeding stock indices. The confidence bounds presented in the assessment report do not adequately reflect (underestimate) the true level of uncertainty in the assessment. Condition 1.1.5.1 (2009) above should address the uncertainty in the assessment.	Simon, Peter and Nick	An extension to 26 April is sought on the original 31 March 10 reporting timeline to bring it in line with the date documents will be sent to workshop participants. See Condition 1.1.1.5 and 1.1.5.1 and Attachment 1.

Condition 1.1.5.3 (2009): All future advice by management to RLIAC, the Minister, and stakeholders must include as a routine feature, "best estimates" of stock status and a forecast of effects of management arrangements. At the same time, the advice must also provide a clear indication of the major uncertainties in current assessments and projections. (See Condition to indicator 1.1.5.1). Progress on this Condition will be determined at the next annual audit as it is only possible to judge at the time major (annual) management decisions are made.	
Condition 1.1.5.3 **Client Response and Action Plan**	**Timeline(s)**
See response to 1.1.1.5 and 1.1.5.1.	Annual audit of 2010

Condition 1.1.5.3 Actions and comments	Person(s) responsible	Timeline & comments
All future advice by management to RLIAC, the Minister, and stakeholders must include as a routine feature, “best estimates” of stock status and a forecast of effects of management arrangements. At the same time, the advice must also provide a clear indication of the major uncertainties in current assessments and projections. (See Condition to indicator 1.1.5.1).	Jo, Nick and Kevin.	Next annual audit (November 10?).

1.1.5.5		
The assessment includes a quantitative evaluation of the consequences of current harvest strategies.		
SG 60	**SG 80**	**SG 100**
The assessment forecasts the consequences of current harvest strategies for the stock. There is moderate confidence in the robustness of the advice.	The assessment includes a robust forecast of the consequences of current harvest strategies. There is a high degree of confidence in the adequacy of the harvest evaluation.	The assessment includes the consequences of current harvest strategies, forecasts future consequences of these and evaluates stock trajectories under decision rules. There is a very high degree of confidence in the adequacy of the harvest evaluation for a robust assessment.

Condition 1.1.5.5

Revised Rationale: The model used for the quantitative assessment of the western rock lobster provides a good basis for evaluating different management options for the fishery and has clearly been useful (and used) to explore combinations of tactical measures to achieve desired catch reductions in the face of concerns about puerulus settlement. However the concerns discussed above about the robustness of the current quantitative assessment also raise concerns about the robustness of the forecasts and do not currently support a high degree of confidence in the adequacy of the harvest evaluation. This indicator clearly meets the first element of the 60 scoring guideline and also meets the second element in the sense that the exploration of management tactics is probably robust to the uncertainties in the assessment.

Condition 1.1.5.1 (2009) above will allow this indicator to meet the 80 scoring guideposts.

Condition 1.1.5.5 Client Response and Action Plan	Timeline(s)
See response to 1.1.1.5 and 1.1.5.1	As for 1.1.5.1

Condition 1.1.5.5 **Actions and comments**	**Person(s) responsible**	**Timeline & comments**
The concerns discussed above about the robustness of the current quantitative assessment also raise concerns about the robustness of the forecasts and do not currently support a high degree of confidence in the adequacy of the harvest evaluation. Condition 1.1.5.1 (2009) above will allow this indicator to meet the 80 scoring guideposts.	Simon, Peter and Nick.	Extension sought to 26 April 10, as for Conditions 1.1.1.5 and l.1.5.1

Appendix 3 – Stock Assessment Workshop Reference Documents

Stock Assessment Workshop Reference Documents

Western Rock Lobster Fishery Harvest Strategy and Decision Rules Framework Proposals – A Discussion Paper (2010). http://www.fish.wa.gov.au/docs/mp/mp239/index.php?0706

Western Rock Lobster Low Puerulus Settlement Risk Assessment Workshop Held 1 and 2 April 2009 at http://www.fish.wa.gov.au/docs/op/op071/index.php?0706

The 2009 SCS / MSC surveillance report. Principle 1 – Stock Assessment is the relevant section.

http://www.msc.org/track-a-fishery/certified/south-atlantic-indian-ocean/western-australia-rock-lobster/reassessment-downloads-1

Western Rock Lobster Stock Assessment and Harvest Strategy Workshop 16 – 20 July 2007 can be found at: http://www.fish.wa.gov.au/docs/op/op050/index.php?0706

Stock Assessment of the West Coast Rock Lobster Fishery (Draft) at http://www.fish.wa.gov.au/docs/frr/frr180/index.php?0401

State of the Fisheries Reports at http://www.fish.wa.gov.au/docs/sof/index.php?0706

Appendix 4 – Additional Stock Assessment Model Diagnostics & Information

Requests from the Panel for additional information prior to and during the workshop resulted in a number of additional model outputs, papers or explanations being provided to the review team.

They included

A) de Lestang. S., Caputi, N. and Melville Smith, R. (2009) Using fine-scale catch predictions to examine spatial variation in growth and catchability of *Panulirus cygnus* along the west coast of Australia. *New Zealand Journal of Marine and Freshwater Research* **43**: 443-455

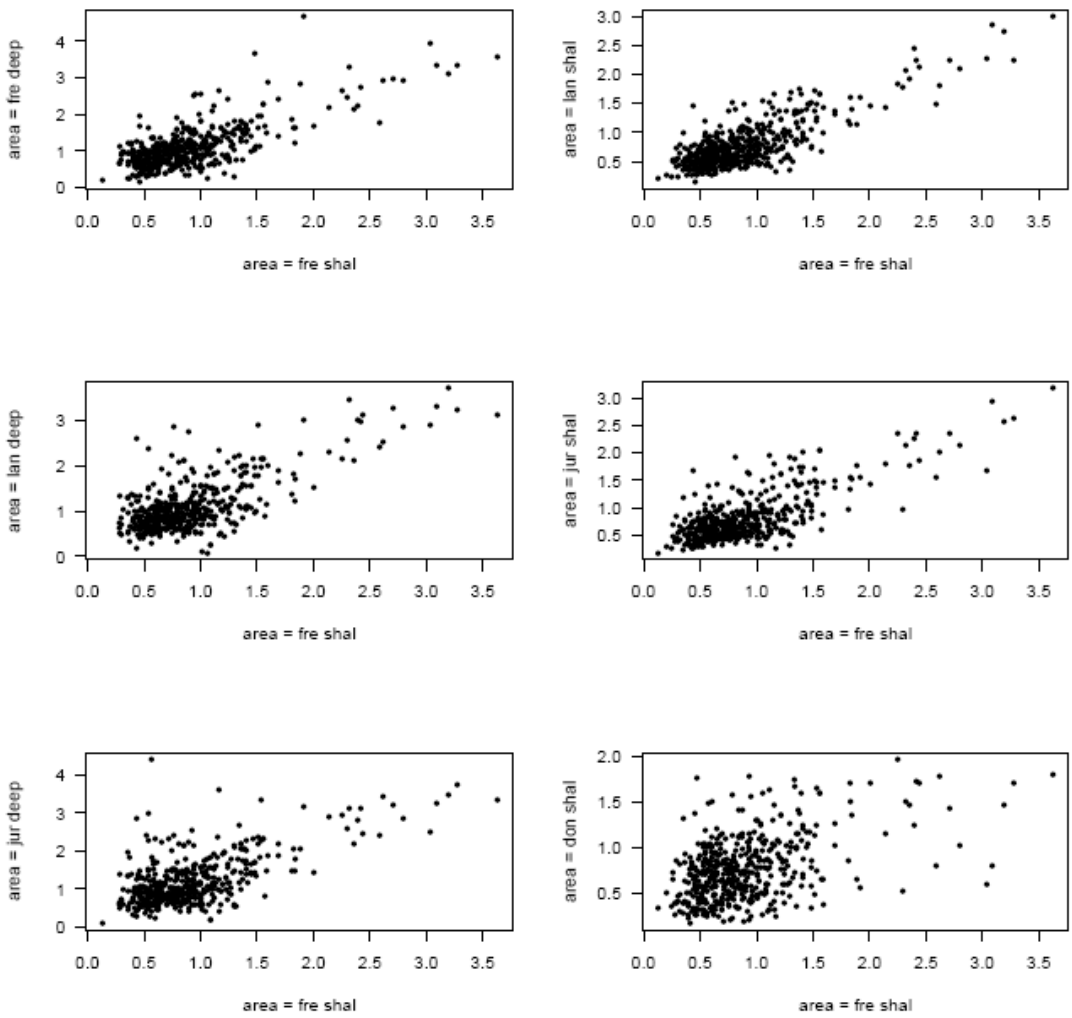
B) Environmental variables used in the model

The only environmental variable used directly in the model was water temperature (Reynolds SST). This was used to adjust the *q* for the red lobsters only and is based on a relationship determined in the catch prediction model (de Lestang etal. 2009 – listed above). This model could not determine a relationship between white lobsters and water temperature. This makes biological sense, since white lobsters are already very active due to their migration, and a slight increase in their activity is unlikely to alter their *q*. The *q* of red lobsters on the other hand is less and therefore far more impacted by small changes in this parameter.

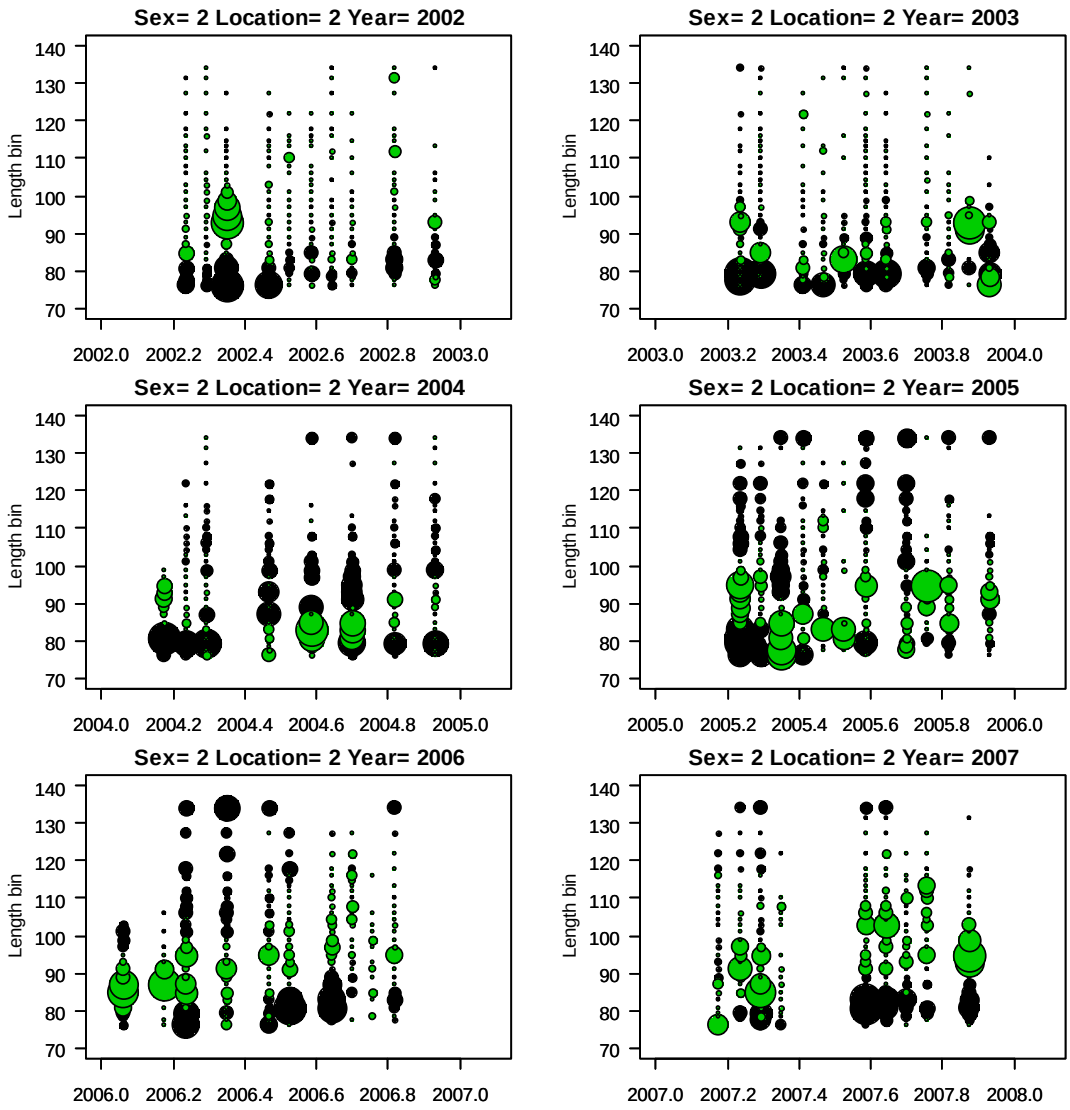
The impact of environmental factors are included in a number of other models used in the western rock lobsters fishery. Only the catch-prediction model, which produces estimates of the power relationship between settlement and recruitment (alpha in the stock assessment model) and between water temperature and q are used in the stock assessment model (all as fixed parameters).

- The independent breeding stock index is derived by a GLM and uses an index of swell height as a factor. This index is not incorporated into the stock assessment model.
- The dependent breeding stock index is derived from a GLM which uses water depth and water depth^2 as covariates. This index is not incorporated into the stock assessment model.
- The catch prediction model uses water temperature (Reynolds SST) as a factor in its non-linear model between puerulus settlement and catch three-four years later. This model estimates the relationship between water temperature and catchability used in the stock assessment model. Estimates of the power relationship between settlement and recruitment (alpha in the stock assessment model) from this model are used as fixed parameters in the stock assessment model.

C) Model fit diagnostics including catch per unit effort comparisons and plots of Pearson's Residuals. Note, only two pages have been provided in this report as an example.



Examples of catch per unit effort comparisons between various cells in the stock assessment model.



Example of plots of Pearson residuals between observed (black) and estimated (green) size composition data by sex, model cell and year.

Appendix 5 – Presentations made by DoF staff

R. Fletcher - Welcome

Welcome
Review Team

- Dr Cathy Dichmont (CSIRO)
- Dr Andre Punt (Univ. Washington)
- Dr Klaas Hartmann (Univ. Tasmania/TAFI)
- Prof. Norm Hall (Murdoch Univ./DoF)

Purpose

- This is a scientific review of the stock assessment model and inputs used for the assessment of the status of the western rock stock and fishery.
- The timing for this review was set to address the issues identified at the MSC review completed in November 2009
- But in reality it is continuing the process of ensuring sensible development of what is a complex modelling task, that was begun in 2007.

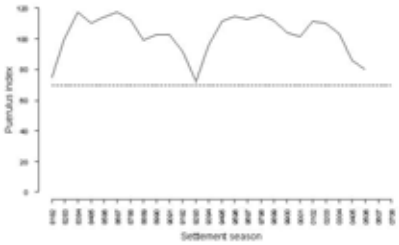
Background 1

- In 2007, stock assessment was entirely empirically based – using FDBSS outputs to determine current status of breeding stock.
- The operational 'objective' was to adjust nominal effort to ensure the effective effort and exploitation rates would keep egg production above threshold levels.
- Management was based on input controls to essentially maintain constant exploitation rates to generate annual varying MSY based catches.

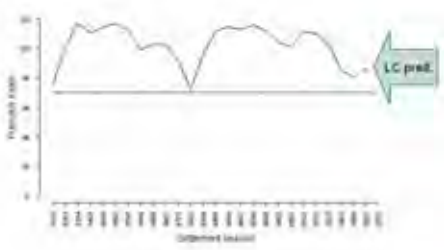
Background 2

- The development of an integrated model had begun in 2006, the prototype was reviewed by 4 independent reviewers in 2007
- Their recommendations were used to generate the first operational model that was used in 2008.
- But the landscape all changed in October 2008

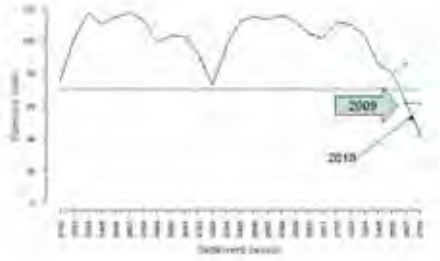
What happened in Oct 08?



Where did we think we would be?



What actually happened?



What happened since then?

- Since October 2008 there has been an intense level of activity
- This includes activities undertaken by research, management and the industry.
- The management arrangements have been adjusted multiple times to accommodate more precise information and the outcomes of previous actions
- Shift from 3-5 year static packages with one year's notice of change - to real time management (multiple per year)
- Shift to effectively a constant escapement policy
- Use of TACCs to control catch, not just effort limit
- Recent announcement to move to ITQ based management
- Intention to use MEY principles as the basis of management, not MSY

Implications for the Model

- The entire landscape of rock lobster fishery has changed since the 2007 stock assessment review
- So, in addition to the specific MSC based questions, the model also needs to be examined to ensure that its structure and outputs are appropriate with:
  - the changes in management methods (ITQs) and objectives (MEY)
  - increased knowledge of source – sink relationships and recruitment dynamics
- Specific set of questions have been developed to assist reviewers in their process (which they can ignore, add to delete etc!)
- We will outline these at the end of the background

Final Notes

- This is a technical workshop to assist the review team provide advice about the series of MSC questions and to help improve the stock assessment model and processes for the future
- The team only has four days to go through a complex series of issues so we cannot afford to get distracted.
- There will be many common technical terms used that we may not have time to explain
- Moreover, it is not a forum to debate management policies.

R. Brown – Objectives of the Workshop

"The Workshop"

- It is a scientific workshop for the expert scientists doing the review and will involve a lot of scientific terminology, which we will not spend a lot of time explaining.
- It is about reviewing our understanding of the rock lobster stock and the way this has been modeled and used for management.
- It is not about quotas and quota allocations

Background of workshop

- MSC re-certification Dec 2006
  - Condition to conduct a review of stock assessment
- Stock assessment workshop 2007
  - Implementation of recommendations
- MSC review Nov-Dec 2009 – Principle 1
  - DoF highlighted planned modelling updates / review
  - MSC additional modelling updates / review
- Most updates completed
- Review part of normal ongoing research process

Workshop process

- Information provided to reviewers
  - Stock assessment model and code
  - 2009 Low puerulus risk assessment report
  - 2007 Modelling and Stock Ass report, etc
- Review reporting requirements:
  - Preliminary findings verbal – Mon 3 to 5 pm
  - Written reports from each reviewer

Primary Objectives

- **Review the stock assessment model** and make recommendations to enhance it. This will include an assessment of the progress made to meet the conditions set by the Marine Stewardship Council's auditors.

Review stock assessment model cont

This will include:

- how uncertainties in the BS indices are dealt with, including how changes in maturity and environmentally induced inter-annual changes in catchability, have been addressed.
- revised time series for estimates of breeding stock, including confidence bounds and the way that they reflect the uncertainties in the analyses.

Primary Objectives

- **Review the 2009 stock assessment**. This will include an assessment of the progress made to meet the conditions set by the Marine Stewardship Council's auditors.
- Issues to be addressed include:
- Estimating depletion within the model by fitting to seasonal trends in catch rates
- Reintroducing breeding stock indices into the objective function.

Review the 2009 stock assessment cont

- Estimating efficiency change within the assessment model
- Identifying key uncertainties in assumptions and data and undertaking appropriate sensitivity analyses
- Estimating the relationship between puerulus settlement and recruitment within the assessment model
- Incorporating size data into the assessment

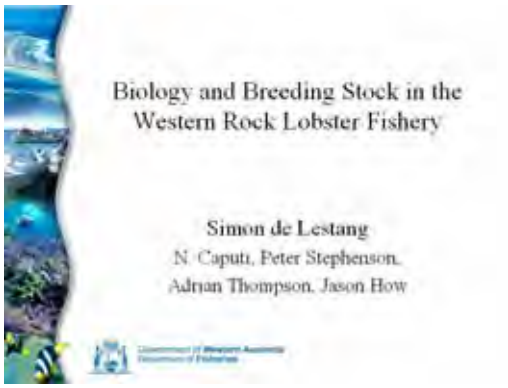
Primary Objectives

- Review the current understanding and measurement of the rock lobster breeding stock.

Secondary Objectives

- Review the proposed Harvest Strategy and Decision Rules.
- Review factors that may be contributing to low puerulus settlement (e.g. source-sink, breeding stock, migration, environmental factors) and management implications.
- Help develop the framework for the bio-economic model that is to be developed and make recommendations on how to integrate it with the stock assessment model

S. de Lestang – Biology and Breeding Stock



Western Rock Lobster
Panulirus cygnus

Endemic to Western Australia

Rock Lobster boat

- < 300 in the fleet
- 50 – 70 feet long
- Carry 130 – 200 pots
- Cruise @ 35 kt

Fishing gear

- Two types of pots
- Pulled daily

Batten or slat

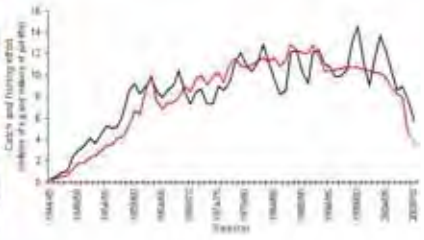
Stick or bee-luve

Management

Input controlled fishery

- Limited entry (69 000 units)
  - Pot usage rate
- Spatial restrictions
  - Further increased through closed areas
- Closed season (1 July – 14 Nov)
  - Further increased through days off
- Minimum and Max size limits
  - Further limited through gauge changes
- Spawning females protected
  - Further increased through setose rule

Annual catch and effort (potlifts)



Life cycle of *Panulirus cygnus*

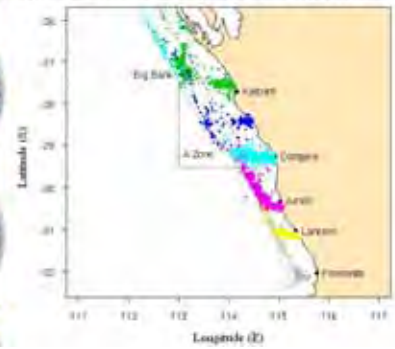
Migrating whites

- Starts full / new moon around 1 Dec
- Move offshore & north
- Comprises ½ annual catch

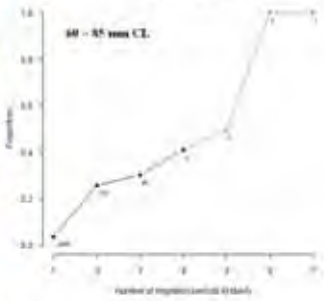
- ~4 years after settlement (60 – 85 mm CL)

- **Results in movement b/w areas**
- **Re-stocks breeding grounds**

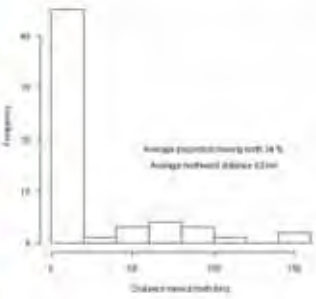
Migration pathway based on all tag-returns



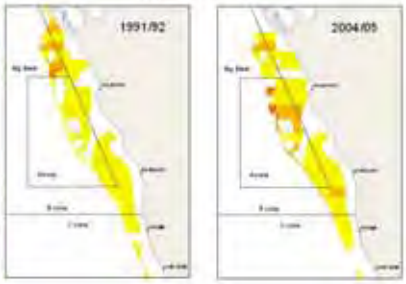
Proportions migrating >10 km vs no. of migrating periods



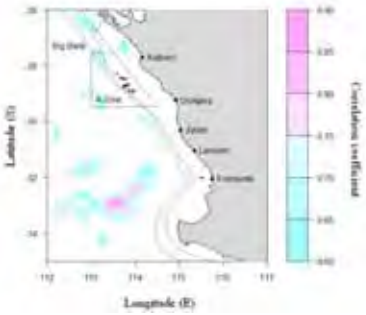
Proportion migrating north



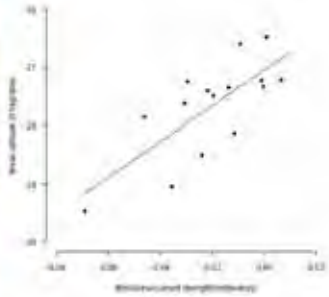
Variation in migration – undersize abundance in deepwater (>20 fm)



Influence of currents on migration



Meridional current vs latitude of migration



Migration - implications

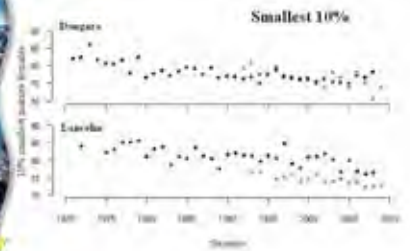
- The impact of migration needs to be improved in model
  - Movement between areas
  - Variation in the magnitude of migration

Egg production indices

- Independent Breeding Stock Survey (IBSI)
  - 1991 - present
- Commercial Monitoring (DBSI)
  - 1971 - present
- Model (MBSI)
  - 1975 - present
- Adjust for:
  - Changes in size at Maturity
  - Changes in fishing efficiency
  - Changes in lobster catchability

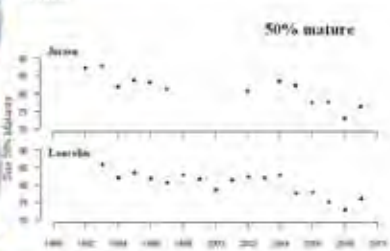
Size at Maturity

•Moved from fixed estimates to equations that incorporate a decline



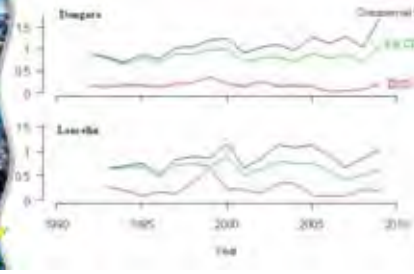
Size at Maturity

•Moved from fixed estimates to equations that incorporate a decline

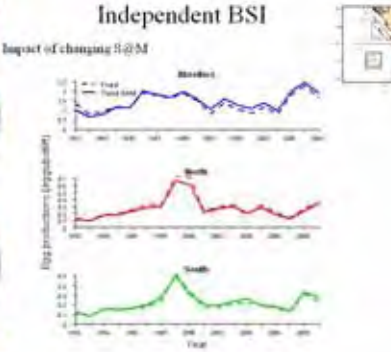


Recent Fishing Efficiency Estimates

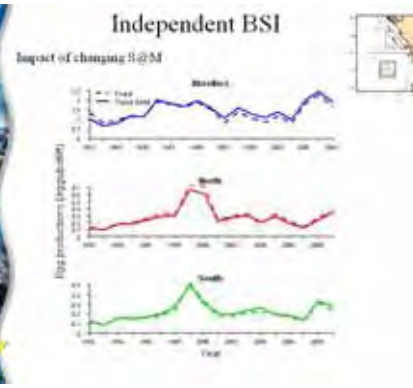
•Based on comparisons b/w IBSS and commercial CPUE



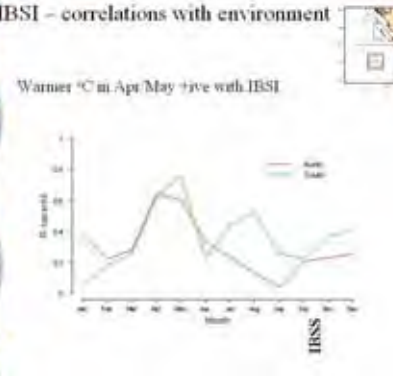
Independent BSI



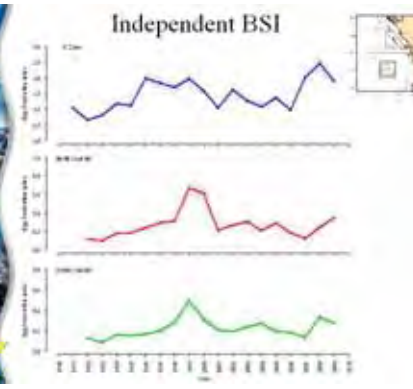
Independent BSI



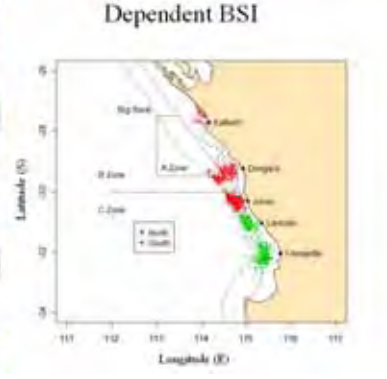
IBSI – correlations with environment

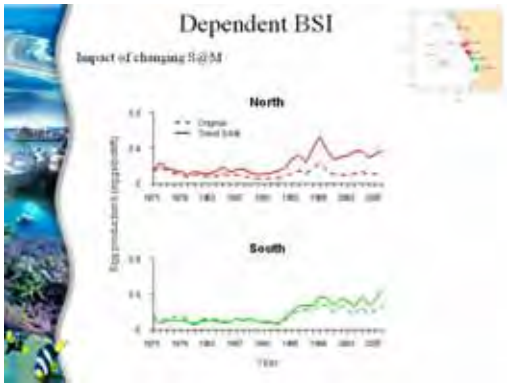


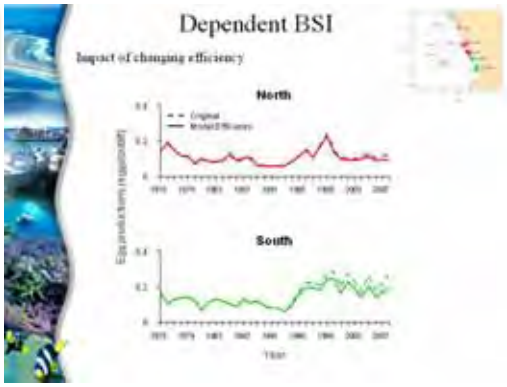
Independent BSI

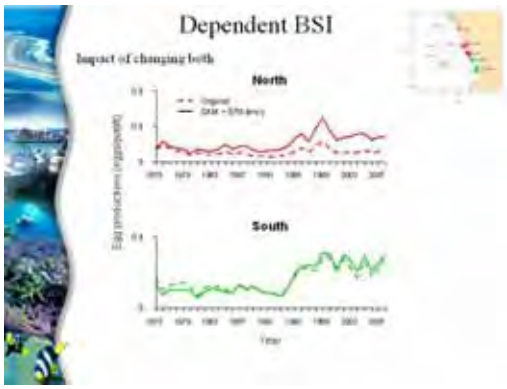


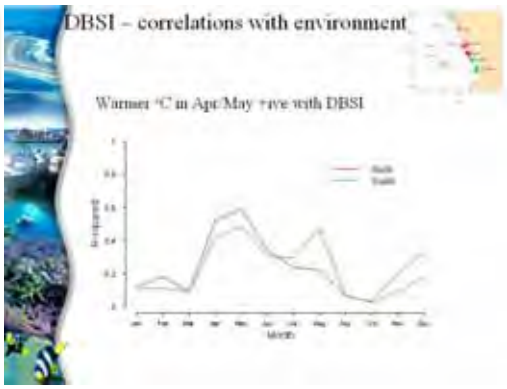
Dependent BSI

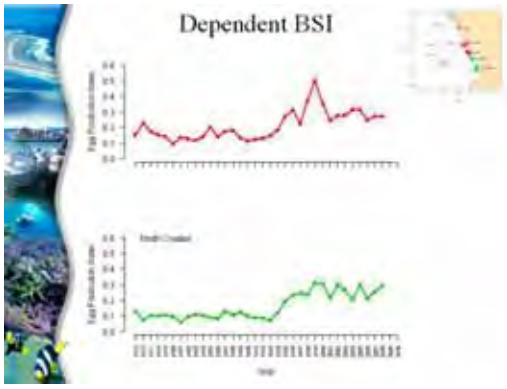


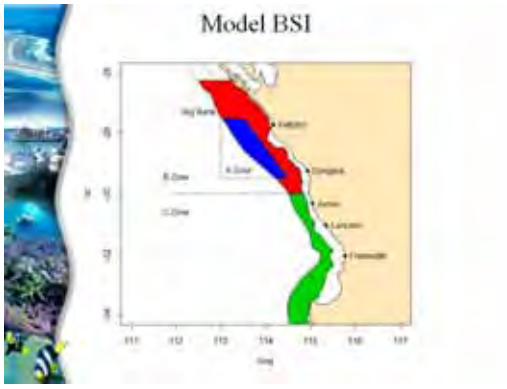

Dependent BSI
Impact of changing S@M
North
South

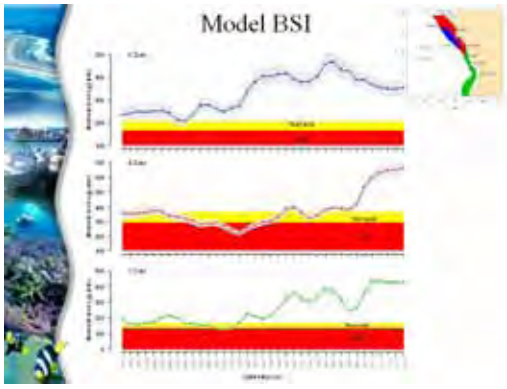

Dependent BSI
Impact of changing efficiency
North
South

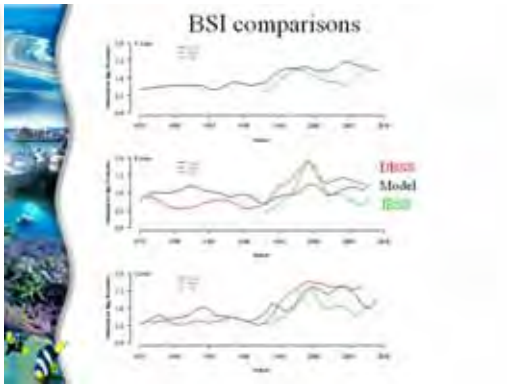

Dependent BSI
Impact of changing both
North
South


DBSI – correlations with environment
Warmer °C in Apr/May +ve with DBSI


Dependent BSI


Model BSI


Model BSI


BSI comparisons
DBSI
Model

P. Stephenson – Model Description

Stock Assessment Model

Peter Stephenson
Simon de Lestang

Stock assessment structure

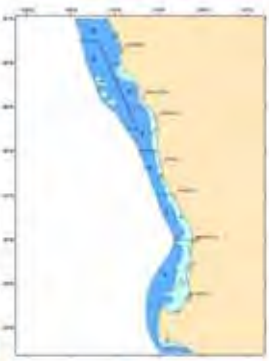
Areas 1-14

Years 1975-2008
future 2014

Time-steps 1-24
Nov 1 to Oct 31

2-year-old recruits enter fishery in time-step 1

Length of recruits from tagging and small mesh potting



Catch[Obs] and Effort

by year (1975-2008), area (1-14), time-step (1-16)
Collected by 1° - 1° Blocks split into deep and shallow and half month by volunteer logbooks (25-35% of fleet)
Recreational catches: ~ 3% of commercial catch

Puerulus[Obs]

collection sites used for catch prediction
Jurien, Dongara : 1968 to present
Alkimos 1993 to present.
Port Gregory 1995 to present
Rat Island 1971 to present

Length composition[Obs]

years 1975-2008, sex 1-2
areas 1-9, 12-14 (Geraldton missing)
time-step 2-16
50 length bins 40 mm - 135 mm

Selectivity

Management rules size

pre 1993	76 mm		
post 1993	76/77 mm	115 mm (B,C)	105 mm (A)
current	77 mm	105 mm (B,C)	95 mm (A)

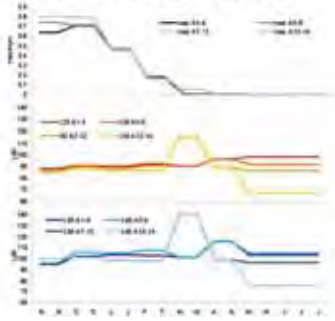
Management rules maturity

pre 1993	ovigerous
post 1993	setose

Gap selectivity:
escape of legals and discard mortality
pre 2009/2010 54 mm gap
current 55 mm gap

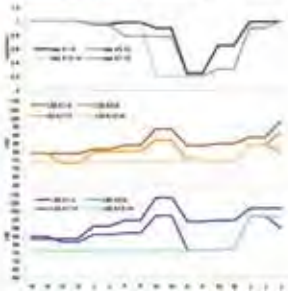
Proportion ovigerous (empirical data, no error)

parameters of logistic function: maximum, L50, L95 common for years 1975-2020. Areas 1-4, 5-6, 7-12, 13-14



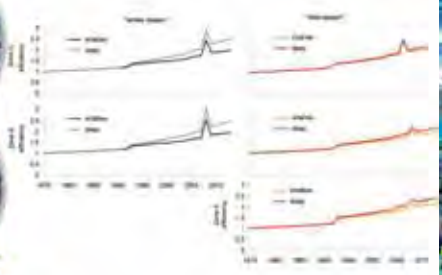
Proportion setose (empirical data, no error)

parameters of logistic function: maximum, L50, L95
Different for years 1975-2020, areas 1-4, 5-6, 7-12, 13-14
L50, L95 decreasing over time. Example 2004



Efficiency (not estimated)

base value of 1% - 2% with jumps due to management changes in 1993, 2005, 2008, 2009



Catchability

$q(V)$: estimated (time-step 1,2 5,6)
$q(W)$: estimated (time-step 3-4)
$q(L)$: estimated (time-step 7-16)

q is related to size (common to sex, area, year). Empirical data

$$v_{y,t,L} = -0.0072\,L_{y,t,L} + 1.151$$

and water temperature by year (1975-2008), area (1-14), time-step (1-16) (empirical data de Lestang)

$$v_{y,t,L} = 1 + 0.01\,(T^{C}_{y,t,L} + 87.46\,T_{y,t} - 1034.68)$$

Fishing mortality

$$F^{C}_{y,t,l,z} = I^{C}_{y,t,l,z}\,E_{y,t}\,q_{l,z}\,w_{y,t,l}\,v_{y,t,l}\,\theta_{y,t,l}$$

Movement

$$N^{a}_{r,y,l,s} = N^{a}_{r,y,l}\,(1 - M_{r,y,l,s}\,\lambda_r)$$

$$N^{a}_{r,y,l,s} = N^{a}_{r,y,l,s} + N^{a}_{r-1,y,l,s}\,M_{r,y,l,s}\,\lambda_r\,v_{r,r-1}$$

Proportions "white" $N^{a}_{r,y,l,s} = K_{r,y,l}\,N(G_{r,y}, \sigma^{2}_{r,y})$

$G_{r,y}$, $\sigma^{2}_{r,y}$ are the mean length, standard deviation of the normal distribution, and $K_{r,y,l}$ is a scaling factor

λ_r is the proportion of the "whites" that migrate

$v_{r,r}$ movement matrix

From	To	Zone C 2,3,5	Zone B 9	Zone B 10	Zone B 12	Zone A 14
Zone C	2,3,5	1	0	0	0	0
Zone B	7	0	0.75	0	0	0.25
	9	0	0	0.75	0	0.25
	11	0	0	0	0.75	0.25
	13	0	0	0	0	1
Zone A	14	0	0	0	0	1

Objective Function of the Stock Assessment Model

1. Catch by area (1-14), year (1975-2008), time-step (1-16)

$$\lambda_1 = \sum_{r,y,l}\left[\frac{C_{r,y,l}}{C_{r,y}}\frac{1}{2\sigma^{2}_{r,y}}\left(\ln(C_{r,y,l}) - \ln(C_{r,y,l}\,\bar{F} + 0.5\ln(2\pi\sigma^{2}_{r,y})\right)\right] \quad \sigma_C = 0.2$$

2. Catch by area (1-14), "whites" period (time-step 1-6) and "reds" period (time-step 7-16).
   year 1975-1992 $\sigma_C = 0.31$
   year 1993-2008 $\sigma_C = 0.14$

Length composition:
multinomial

$$\lambda_2 = \sum_{r,y,l}\left[N_{r,y,l}\ln(\hat{P}_{r,y,l})\right]$$

Model and observed catches 1990/91-2010-2011

Objective Function: recruitment

Lobster recruit in time-step=1, age= 2 $N^{a}_{r,y,1,2} = \mu_y\,\beta_r R_r\,\varphi_2\exp(\varepsilon_{r,y})$

R_r average recruitment in area r φ_2 proportion of each sex

β_r proportion residing in each region, $\sum\beta_r = 1$ for r = area and estimated for r = zone

φ_2 proportion in each length class $\varepsilon_{r,y}$ regional recruitment deviation

This related to previous lagged 2 years $\hat{P}_{r,y}$ caused by a density dependence term α_y

$$\alpha^{P}_{r,y} = \alpha_y \ln(\hat{P}_{r,y}) - \frac{\sum_{y=1975}^{2008}\alpha_y \ln(\hat{P}_{r,y})}{2008-1975+1}$$

Contribution to objective function is

$$\lambda_3 = \sum_{r=\text{zone}}\sum_{y=1975}^{2008}\left[\frac{1}{2(\sigma^{P}_{r,y})^2}(\alpha_{r,y} - \alpha^{P}_{r,y})^2 + 0.5\ln(2\pi(\sigma^{P}_{r,y})^2)\right]$$

$\sigma^{P}_{r,y}$ is the cv of the observed annulus data

Zone A,B parameter estimates

Residuals ln(pred C) – ln(obs C)

zone C that is areas 1-6

Egg production with 50% CI's

$$\Theta_{s,y} = \sum_{r=1}^{14}\left[\frac{1}{1+e^{-\ln(81)\frac{L-L_{50}}{L_{95}-L_{50}}}} - \frac{1}{1+e^{-\ln(81)\frac{L-L_{50}}{L_{95}-L_{50}}}}\right] f\cdot L^{b}\cdot N^{a}_{r,y,1,2}$$

f and b are fecundity parameters

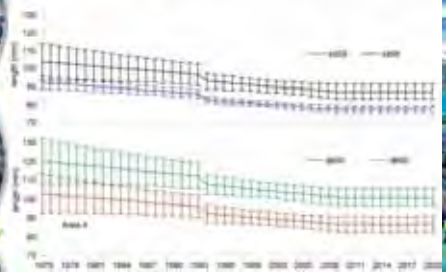
The measurement error is incorporated as an eval and as output report

a. $M = M + 0.02 \cdot N(0,1)$
b. recruitment cv's
   $R = R + R*cv*N(0,1)$
c. maturity parameters
   $L50 = L50 + \sigma*N(0,1)$

SEE NEXT SLIDE)

Maturity parameters[a] of the maturity logistic function

Years 1975-2009. Areas 1.2 (Fremantle), 3-4 (Lancelin), 5-6 (Jurien), 7-10 (Dongara, Geraldton), 11-12 (Kalbarri), 13-14 (Abrolhos) Example Area 4



Egg production with 50% CI's

$$\Theta_{a,y} = \sum_{l=L_a}^{\infty} \left(\frac{1}{1+a^{-\ln(19)\frac{l-L_{50}}{L_{95}-L_{50}}}} - \frac{1}{1+a^{-\ln(19)\frac{l-L_{50}}{L_{95}-L_{50}}}} \right) f \cdot \bar{L}^{b} \cdot SP_{y,l,1,1}$$

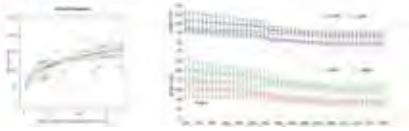
f and *b* are fecundity parameters

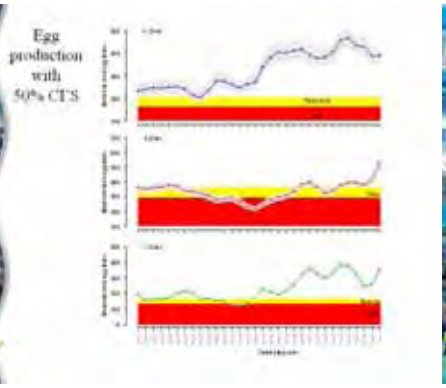
The measurement error incorporated in unceval and in output report

a. $M=M + 0.02 \cdot N(0,1)$

b. recruitment cv's:
$R=R + R*cv*N(0,1)$

c. maturity parameters
$L50=L50 + \sigma*N(0,1)$





Data not used in the assessment model

Egg production:

a. Independent Breeding Stock Index (IBSI)

b. Dependent Breeding Stock Index (IBSI)

Grade category data:

Years 1965 to present. Areas whole fishery

Movement between Zone C and Zone B

This has become more important at the current lower harvest rates. Incorporation will entail continuing the ZoneAB model with the Zone C model and will necessitate reducing the complexity (reducing areas and time-steps).

S de Lestang – Stock Assessment 2009/10

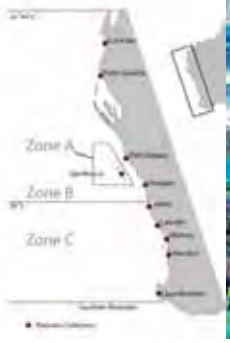
Recent stock assessment and management changes in the Western Rock Lobster Fishery

Simon de Lestang
N. Caputi, Peter Stephenson, Adrian Thompson, Jason How

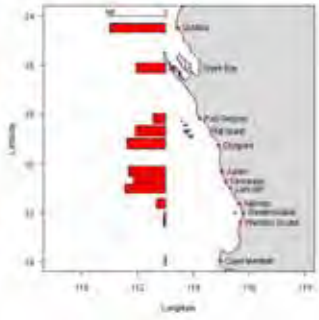
Outline

- Puerulus recruitment
- Mesh pot survey
- Impact on catch and effort
- Impact on CPUE
- Impact on breeding stock

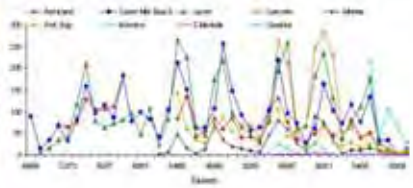
Puerulus Settlement



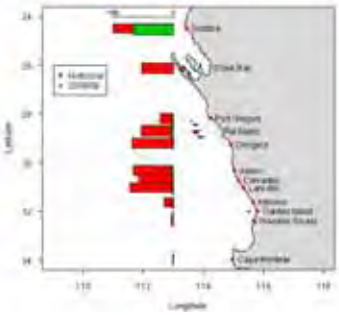
Large spatial variation in settlement



Large temporal variation in settlement



2008/09 – settlement in the north

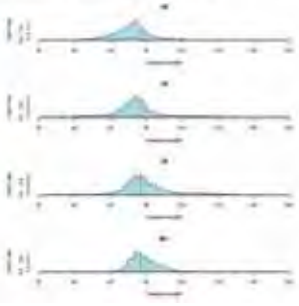


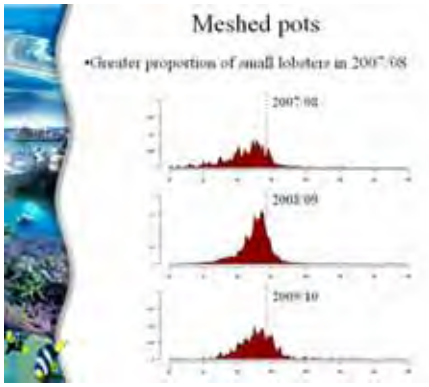
Meshed pots

- Fished by commercial fishers
- Examine distribution and abundance of small lobsters

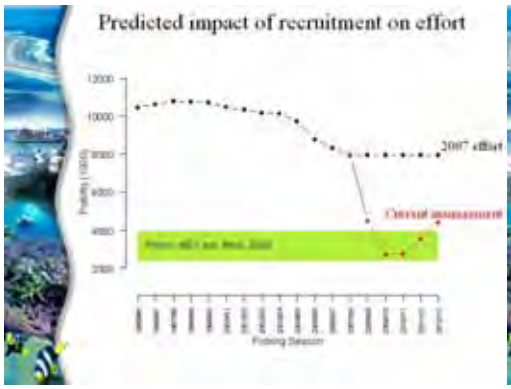
Meshed pots – 2009/10

- No indication of deepwater settlement

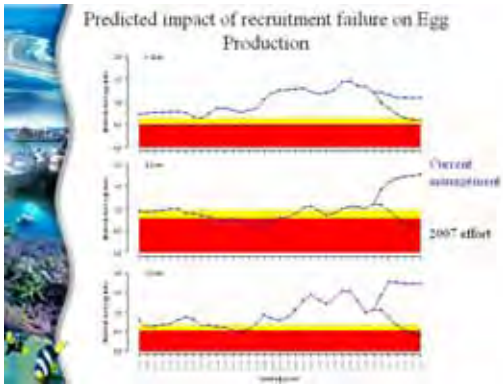



Meshed pots
•Greater proportion of small lobsters in 2007/08
2007/08
2008/09
2009/10


Predicted impact of recruitment on catch
2007 effort
Current management


Predicted impact of recruitment on effort
2007 effort
Current management


Predicted impact of recruitment on catch rates
Current management
2007 effort


Predicted impact of recruitment failure on Egg Production
Current management
2007 effort

K Donohue – Harvest Strategy and Decision Rules

Harvest Strategy/Decision Rules Western Rock Lobster Fishery

Kevin Donohue
Nick Caputi, Simon de Lestang,
Rhys Brown, Rick Fletcher

20 May 2010

Contents

Fisheries Management Paper 239

- Biological Objective
  - Indicator
  - Reference values
  - Performance
- Economic Objective
  - Future Directions
- Setting Zonal TACCs under Quota

Decision Rule Framework Driving Management

- Understandable by stakeholders
- Transparency in decision making
- Provides targets to focus management decisions
- Can assess outcome of management options
- Performance monitored and evaluated
- Flexibility to consider changes for other reasons (economic).

Management Arrangements

1963 +	Limited Entry, Effort controls (pots)
2008/09	Effort controls Catch target = 7,800 t
2009/10	Effort controls Competitive catch target = 5,500 t Competitive zonal targets
2010/11	Effort controls Quota = 5,500 t Zonal quotas Individual catch limits
2011/12 +	Less effort controls Quotas

Biological Objective

Ensure that the breeding stock in each zone remains above its threshold level, and the probability of it still being above this level in five years time is 75%.

Breeding Stock - Indicator

Indicator

- Egg production

Measures

- Empirical
  - Fishery-Dependent Breeding Stock Index (1970s)
  - Fishery-Independent Breeding Stock Index (1990s)
- Model derived

Model

- Fitted to empirical data
- Broader Spatially
- Evaluate management options
- Future predictions
- Estimate of errors available
- Values change with model updates

Egg production per zone

- Calculated independently for each zone
- Relative measure comparable to historical levels
- Need to address importance of spatial distribution of egg production **within** zones (eg Big Bank)
- Issues
  - Taking into account interaction between zones (migration)
  - Appropriateness of scale of management by zone

Threshold values

Zones B & C

- Average 1980 to 1982
- Lower period of exploitation, pre-efficiency improvements (Colour sounders, GPS)
- Thresholds above the historical minimum

Zone A

- Average 1984 to 1987
- Size of maturity lower in Zone A
- Threshold at historical minimum most breeding stock under minimum size

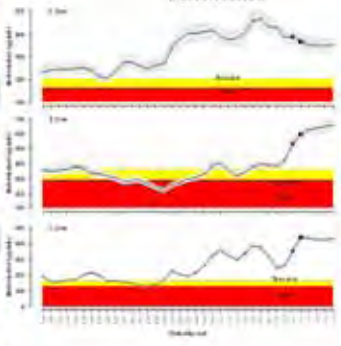
Five year period

- Settlement provides for catch predictions four years ahead.
- Fifth year based on assumption of low settlement.
- Long lead in time period to adjust.

Probability

- Minimum 75% above threshold variable within the five year period.
- Should it be higher in the short term (90%)?
- Should it be lower in the long term (75%)?
- Flexibility for breeding stock fluctuations within the time period.

Performance



FMP 239 -Economic Part

Objective:	Ensure that the harvest rates for the fishery are consistent with the principles of Maximum Economic Yield
Indicator:	HR=C/(C+Residual Legal Biomass)
Ref Value:	Target (40% of 2007/08 effort?)
Performance:	HRate higher than MSY

Questions for reviewers

How should the framework change in moving from MSY under input controls to MEY under Quotas?

- Is the biological objective still appropriate?
- What should be the economic objective – MEY?
- What is the best indicator to use for the economic objective (Harv. Rate, Egg Index, Yield)?
- What should be the economic reference value(s) – target only?
- How are the two objectives considered concurrently?

Setting Zonal TACCs

Methods

Current

1. Maximum sustainable catch per zone scaled to predetermined fishery maximum catch (5,500t) – variable egg indexes per zone.

Future possibilities

1. Maximum sustainable catch per zone scaled to predetermined fishery maximum catch - variable egg indexes per zone.
2. Same egg index for all zones at end of 5 years (say 2.0)
3. Variable egg index at end of 5 years, based on MEY
4. Same HR for all zones at end of 5 years (say 40%)
5. Variable HR for all zones at end of five years, based on MEY

Questions

N Caputi – Environmental Effects on Puerulus and Migration

Overview

1. FRDC/New research projects overview
2. FRDC Oceanography study: source-sink
3. FRDC breeding stock - environmental factors affecting settlement
4. *Breeding stock – Big Bank (Simon)*
5. *Environmental factors affecting migration (Simon)*

Risk Assessment workshop 2009 on low puerulus settlement - Conclusions

- Short-term environmental (unlikely-possible)
- Long-term environmental (possible-likely)
- Part of Breeding stock (possible)
  - Northern area (eg Big Bank, North Abrolhos)
- Combination (likely)
- Puerulus collector measurement error (remote)

New Research Projects Related to Puerulus Settlement Issues (DoF, CSIRO, Uni's, DEC, Industry)

1. Oceanographic larval modelling: source – sink
2. Environmental & breeding stock causes/correlations
3. Biological oceanography of larvae July 2010
4. Genetic variation: source - sink
5. Expansion in collector sites to Coral Bay
6. Measuring other species on collectors
7. Fishing efficiency – Breeding Stock Measurement
8. Big Bank Survey
9. Small-mesh pot sampling juveniles (in season)
10. Small –mesh pot pre-season (industry)
11. Effects of fishing in deep water - carrying capacity
12. Environmental factors affecting migration

Factors affecting puerulus settlement

(DoF & CSIRO)

Period: 2009

Preliminary oceanographic model (source-sink)

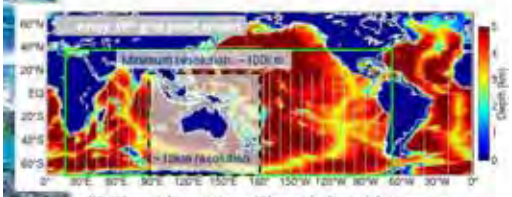
Period: 2010-2012

1. Oceanographic model (annual variation)
2. Environmental factors (water temperature, current, wind, productivity, eddies) & breeding stock affecting puerulus
3. Climate change trends

Oceanographic larval modelling Team

- **Nick Caputi, Jim Penn, Simon de Lestang, Alan Pearce Nieves Felipe** (Department of Fisheries)
- **Ming Feng, Dirk Slawinski, Evan Weller** (CSIRO)
- Review workshop: September 2009
- Reviewers:
  - Bruce Phillips (Curtin Uni), David Griffin (CSIRO)
- Review workshop: November 2009
- Draft final report December 2009 (1st FRDC project)
- Commenced 2nd FRDC project 2010

Oceanographic model - BRAN



- BRAN spatial resolution ~10km grids Austral-Asian region
- 47 depth layers
- Upper 200m represented by 10m thick layers and progressively coarsening down to 5000m.
- 20m minimum water column (2 layer minimum).
- January 1993 to May 2008.

Oceanographic Model Criteria

Used to assess how realistic the model is

2009 model:

1. **Phyllosoma distribution (general)**
2. **Phyllosoma distribution (specific stages)**
3. **Monthly pattern of puerulus settlement**
4. **Spatial pattern of puerulus settlement**

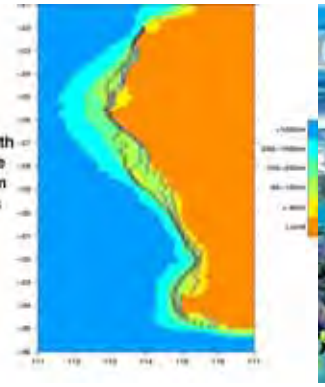
2010-12 model (annual variability):

5. Effect of Leeuwin Current on settlement
6. Variation in the timing of peak settlement
7. Effect of LC on mean Latitude of settlement
8. Impact of SST on puerulus settlement

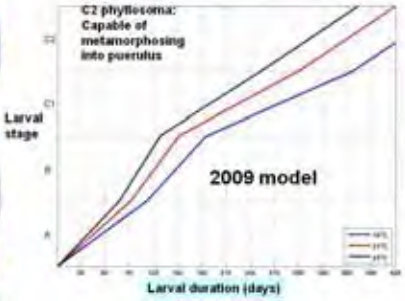
Biological parameters for 2009 model (Review of larval papers – J Penn)

- Spawning/ hatching patterns and locations
- Phyllosoma larval categories [stages]-development
- Duration of each larval category
- Larval growth – possible temp. effects
- Larval mortality - temperature limits
- Metamorphosis larvae to puerulus – triggers/locations
- Puerulus movements
- Puerulus settlement

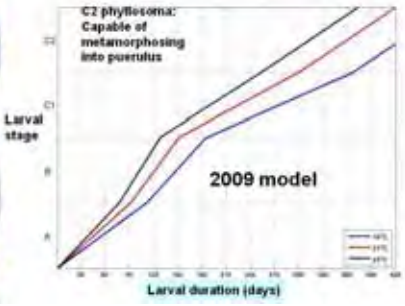
•Locations/depth of larval release
•40, 60, 80-100m
•Equal releases



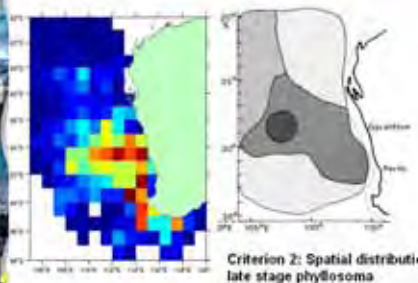
Temperature-dependent growth rates by larval stages



Temperature-dependent growth rates by larval stages

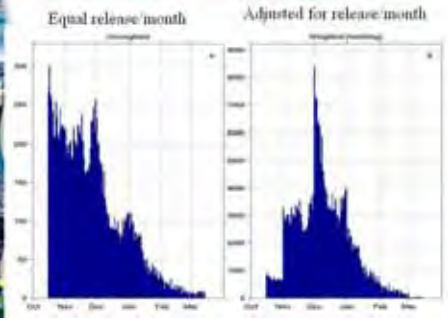


Spatial distribution of category C phyllosoma in July of a typical year in 2009 model

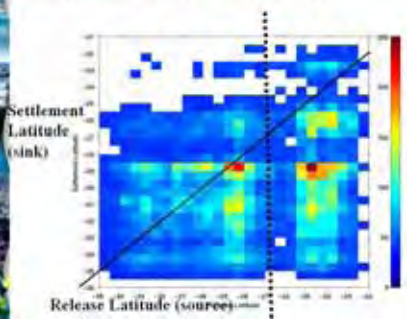


Criterion 2: Spatial distribution of late stage phyllosoma

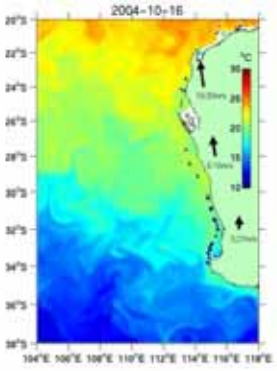
9-year distribution of daily releases of successfully returned puerulus



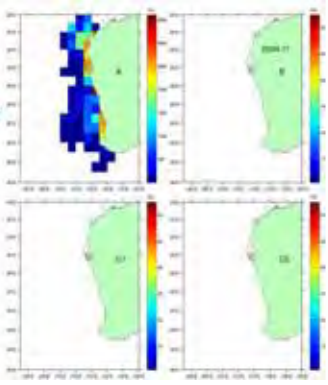
9-year average source-sink relationshi p for puerulus (equal releases)



Movie: dispersal tracks of successfully settled larvae 2005/06 season



Movie: monthly larval distribution



Preliminary Conclusions - oceanographic

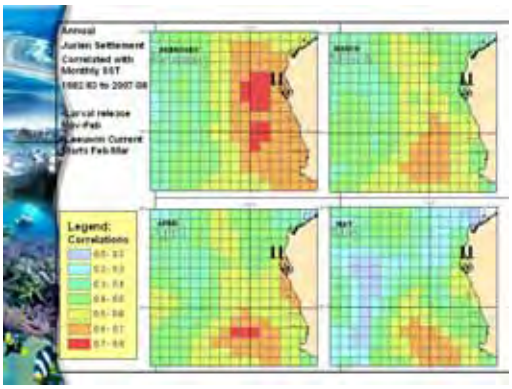
- Preliminary model satisfied 4 key criteria
- Larval movement alone and constant larval growth not sufficient to satisfy criteria
- Temperature-dependent growth/survival of larvae required to satisfy criteria
- Early larval release (Nov) provides greater chance of survival to puerulus than late release (Feb)
- Larvae released in deep waters (60-80 m) more successful than shallow (40 m)
- Larvae released northern region more successful than southern - relative contribution varies annually
- 2010-12 Fine-tune model for 4 other criteria (annual variation)

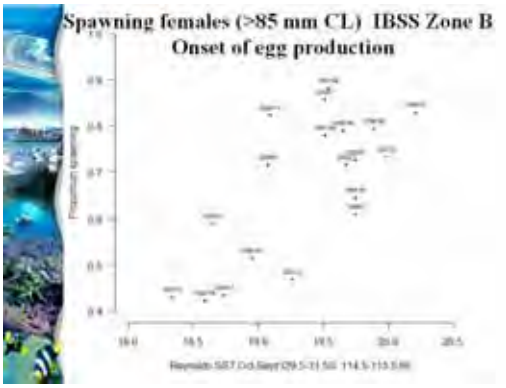
Environmental effects on puerulus

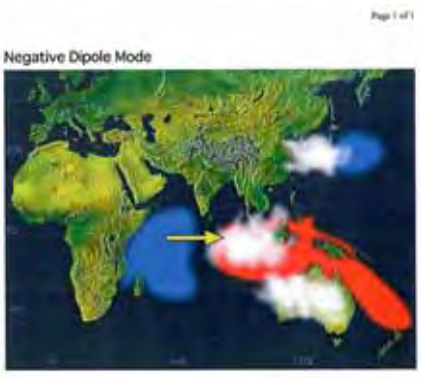
1. SOI/Leeuwin Current (Fremantle sea level- FSL)
2. FSL/SST (Feb-Apr) - early larval phase (survival)
3. Storm (rain Jul-Nov) – late larval phase (advection EW)
4. Leeuwin Current (June-Dec) – late larval phase (advection North-South)
5. SST prior to spawning
6. Easterly winds moving early stage larvae offshore
7. Westerly winds at time of settlement
8. Current strength and direction
9. **Wave strength and direction**
10. Productivity (ChlA)
11. Eddy structure (correlated to FSL)
12. Indian Ocean Dipole

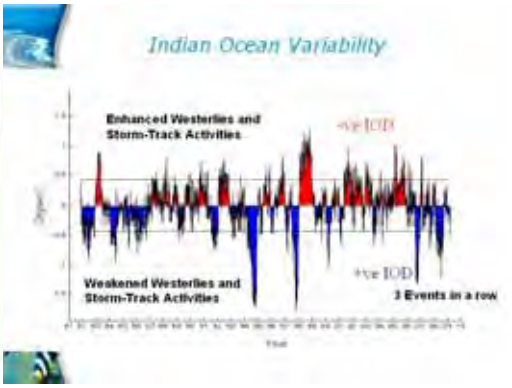
Biological oceanography of larvae (UWA, Murdoch, CSIRO, DoF)

- Southern Surveyor July 2010 (also 2011?)
- FRDC Objectives
  1. Analyze phyllosoma densities, sizes, genetics at 4 latitudes (Rottnest-Shark Bay)
  2. Analyze offshore food web structures supporting phyllosoma growth at sea
  3. Assess potential for Leeuwin Current autumn bloom to support phyllosoma growth



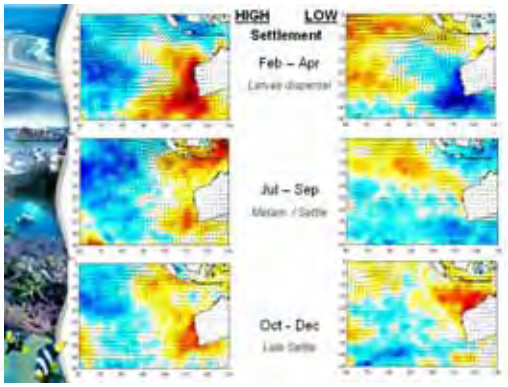






Years of High and Low Puerulus Settlements

	Negative IOD	Neutral	Positive IOD
El Niño		1969 1977 1983 1987 1991 1992 2002 2004 2009	1994 1982 1997 2006
Neutral	1996 1998	1968 1970 1971 1973 1976 1978 1979 1980 1981 1984 1986 1988 1990 1993 1995 2001 2003 2005	1972 2007
La Niña		1974 1975 1985 1989 1999 2000	2008



Preliminary conclusions - statistical

- ENSO, weak Leeuwin Current, cooler SST
  - –ve effect on settlement
  - 2006/07 settlement explained
  - 2008/09 settlement **not** explained
- Westerly winds winter/spring (late larval/puerulus stage)
  - +ve effect on settlement
- Positive IOD for 3 years 2006-08
  - –ve effect on settlement
  - Positive IOD with La Nina in 2008 (1st in 30 yrs)
- Easterly winds Jan/Feb (early larval stages)
  - +ve effect on settlement
- Warm temperature pre-spawning
  - Early spawning & +ve effect on settlement?
- Breeding stock
  - Within historic range for main fishing areas
  - Below historic range north of Abrolhos

Preliminary conclusions – migration/breeding stock

- Big Bank fishery increased since 1990s
- Northerly migration below average 6/last 8 yrs
- Deep water areas north of Abrolhos dependent on migration
- Big Bank survey 2009 – lack of small lobsters
- Big Bank closed for 2009-10

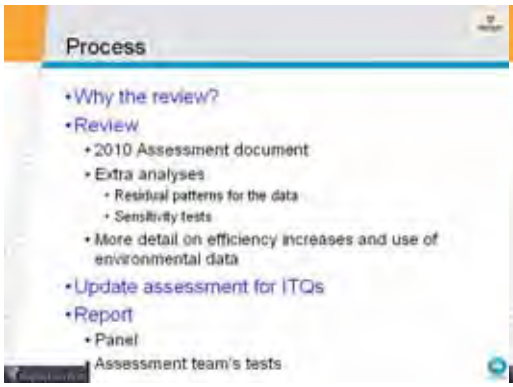
Preliminary conclusions – plausible hypothesis

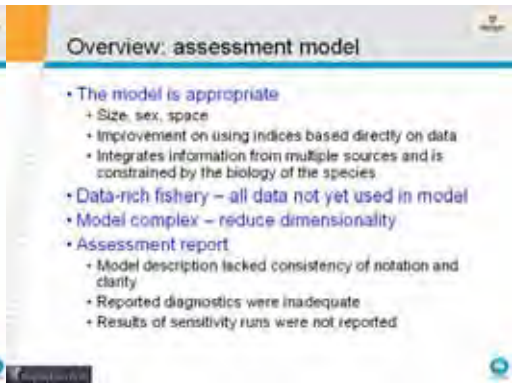
1. Reduced egg production north of Abrolhos
   - poor whites migration north
   - fishing pressure
2. Environmental factors affecting settlement
   - eg increased frequency +ve IOD & ENSO events

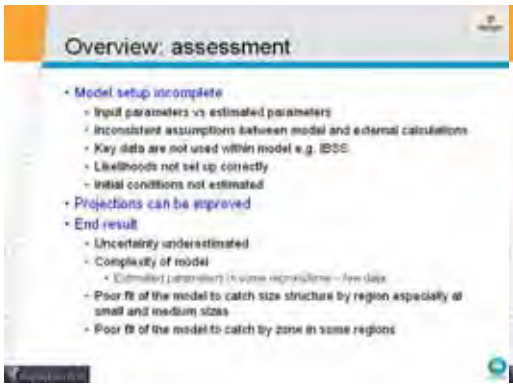
Management options?

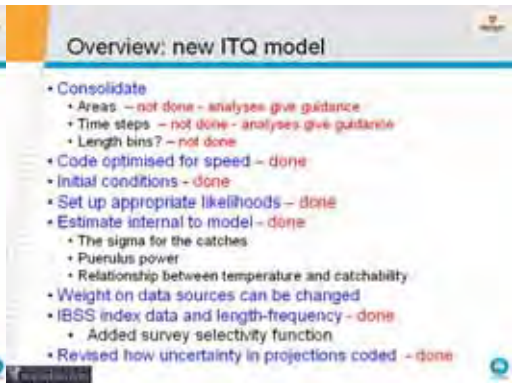
1. Reduce harvest rate to enhance migration
2. Increased protection of lobsters north of Abrolhos (eg Big Bank closure)
3. Monitor breeding stock and develop separate decision-rule framework for north of Abrolhos

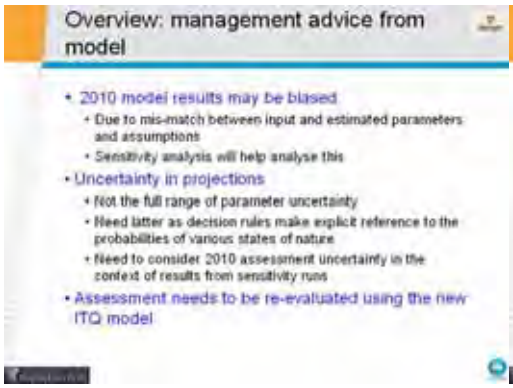
Appendix 6 –Presentation by Review Panel



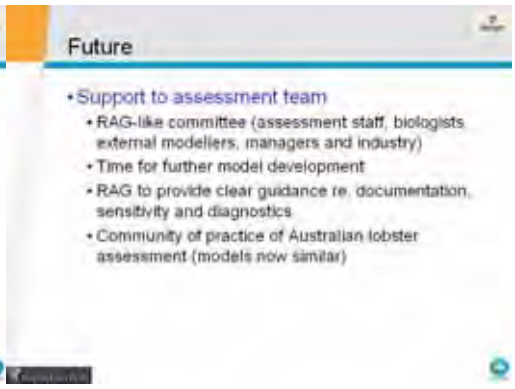


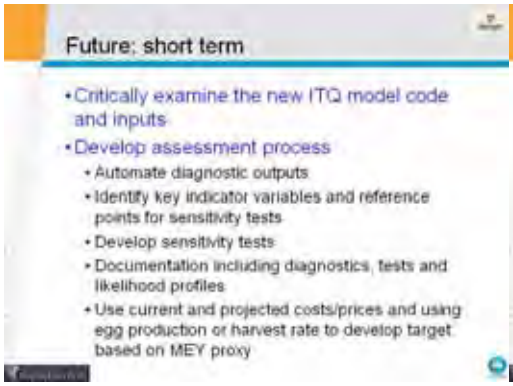


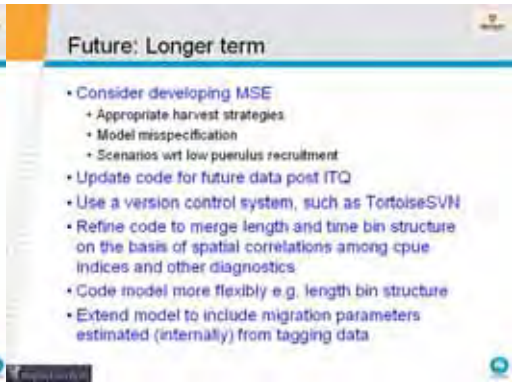





Harvest strategies
• Policy components of the decision rules not reviewed
• Structure of the decision rules are consistent with world's best practice
• Need to define target reference points based on harvest rate (or an egg production level that achieves this harvest rate) representing a proxy for MEY
• Response to decision rules needs to be specified, with allowance for exceptional response if strong scientific support
• The current assessment probably under-estimates the true nature of uncertainty
• Either
• The performance of the decision rules cannot be evaluated without further analyses


Future
• Support to assessment team
• RAG-like committee (assessment staff, biologists external modellers, managers and industry)
• Time for further model development
• RAG to provide clear guidance re. documentation, sensitivity and diagnostics
• Community of practice of Australian lobster assessment (models now similar)


Future: short term
• Critically examine the new ITQ model code and inputs
• Develop assessment process
• Automate diagnostic outputs
• Identify key indicator variables and reference points for sensitivity tests
• Develop sensitivity tests
• Documentation including diagnostics, tests and likelihood profiles
• Use current and projected costs/prices and using egg production or harvest rate to develop target based on MEY proxy


Future: Longer term
• Consider developing MSE
• Appropriate harvest strategies
• Model misspecification
• Scenarios wrt low puerulus recruitment
• Update code for future data post ITQ
• Use a version control system, such as TortoiseSVN
• Refine code to merge length and time bin structure on the basis of spatial correlations among cpue indices and other diagnostics
• Code model more flexibly e.g. length bin structure
• Extend model to include migration parameters estimated (internally) from tagging data

Appendix 7 – Review Panel's Report

REPORT OF THE EXTERNAL REVIEWERS TO THE 20-24 MAY 2010 WESTERN ROCK LOBSTER WORKSHOP

Cathy M. Dichmont, Norman G. Hall, and André E. Punt

EXECUTIVE SUMMARY

- A length-, sex- and spatially-structured population dynamics model, such as that being developed by the Department of Fisheries (DoF), is an appropriate basis for conducting stock assessments and providing management advice for the Western Rock Lobster Fishery. This model is an improvement on using indices based directly on data collected from the fishery because it integrates information from multiple sources and is constrained by the biology of the species.
- The 2010 stock assessment[3] is very complicated, which makes evaluating model robustness difficult. Efforts should be undertaken to reduce the dimensionality of the model.
- Insufficient diagnostic statistics are available to fully evaluate the robustness of the 2010 stock assessment. The statistics examined during the workshop highlighted that some of the data sources are poorly mimicked by the model.
- The data available for the stock are used inconsistently in the 2010 stock assessment. It is necessary to estimate more parameters within the assessment and to use as many data sources as possible. This is particularly important if the measures of precision from the assessment are to be used in decision rules.
- In relation to the questions posed by the MSC auditors, some issues relating to uncertainty have been addressed in the new ITQ model developed during the workshop, while the report contains recommendations to ensure that other sources of uncertainty are considered appropriately in future assessments. Efficiency increases and the influence of environmental factors on catchability were considered in the 2010 stock assessment, but it is recommended that estimation of parameters using these data be incorporated directly within the assessment to ensure consistency of assumptions and to fully account for the uncertainty associated with those data.
- Decision rules for the fishery need to be modified to reflect the State Government's decision to move from an input- to an output-based management system. In particular, these rules need to include a target reference point associated with the proposed Maximum Economic Yield (MEY) objective and should specify an explicit management response sufficient to achieve management objectives within a reasonable time frame.
- A number of other prioritized technical recommendations were made by the Panel. In summary, these relate to validating and refining the new ITQ model developed during the workshop, developing a comprehensive set of diagnostics and

[3] This report refers to two assessment models. The model that was provided to the Review Panel before the workshop is referred to as the "2010 stock assessment" whereas the modified version provided to DoF by the Review Panel at the end of the workshop is referred to as the "new ITQ model".

sensitivity runs that should accompany the results of the base case assessment in future stock assessments, refinement of the decision rules to allow for the introduction of ITQs and an MEY objective, and the development of a Management Strategy Evaluation framework to ensure that management strategies and assessments are likely to be robust under alternative hypotheses relating to, inter alia, the decline in puerulus settlement.

- A Research Assessment Group should be established to facilitate ongoing development and testing of the stock assessment. Considerable benefit and synergy may also be obtained through development of a community of practice for lobster stock assessment scientists, as many of the assessment models that are being used have very similar structures. Further development of the Western Rock Lobster assessment model will demand considerable staff time.

Key note: The integrated stock assessment model for the Western Rock Lobster Fishery, which was presented for review during the workshop was still being developed and the assessment report was consequently not yet in a final form at the time of the review. This workshop therefore furthers the process of continual development of the stock assessment model and associated harvest strategies. Such review is a normal element of the modelling and stock assessment process. The Review Panel notes that some of its recommendations are already on the "to do list" for DoF staff, but are nevertheless included here for completeness.

Introduction

The workshop took place from 20-24 May 2010 at Hillarys in Perth, Western Australia. The objectives of the workshop were motivated by the audit conditions set by the Marine Stewardship Council's Auditors (an extract of key conditions in Appendix A) for the Western Rock Lobster Fishery (WRLF), as well as the need for regular review of the 2010 stock assessment. The objectives of the workshop were further extended by a series of questions posed by Dr Rick Fletcher (Appendix B). These questions formed the focus for the workshop and this report. However, the Review Panel (henceforth Panel) was also aware that the fishery is moving to ITQs and that some recommendations would also need to be considered in that context. The workshop (see Appendix C for the draft agenda / work plan) involved presentations by the workshop participants (see Appendix D for a full set of attendees) and work sessions to modify the code implementing the model. The documents provided to the Panel prior to the workshop (see Appendix E) were augmented during the workshop by working documents prepared in response to requests by the Panel.

The urgency of refining the current integrated model, development of which commenced approximately two years ago, is increasing due to the marked decline in puerulus settlement that has been experienced since 2008 as well as the move to ITQ management. This means that managers require confidence that their response to the decline has been adequate and that the assessment model can accommodate the changes in data required for stock assessment of the now ITQ-controlled fishery. This required that the previous empirical model relating the puerulus index and predicted catch was replaced by a stock assessment model. The model also needed to be modified to include more of the available data, particularly the fishery-independent data that are essential for an ITQ-managed fishery. This workshop therefore occurred during this ongoing process.

This document summarizes the views of the Panel (see Appendix F for short biographical summaries for each panel member). The remainder of this report is divided into several broad topics reflecting the questions in Appendix B. Although the comments and recommendations by the Panel have been divided into three major themes, there is considerable interaction among the various themes and considerations under one theme are related to those under other themes. The final section of the report provides a list of all of the recommendations arising from the workshop (some of which were addressed during the workshop).

The Panel developed an alternative framework for the assessment during the workshop. This framework (see Appendix G) rectifies several of the major concerns raised by the Panel. However, there was insufficient time during the review to test this framework. The Panel **recommends** that the assessment scientists review Appendix G (and the associated software) and, once is has been fully evaluated, base future assessments on it.

The Panel thanks the staff of the WA Department of Fisheries, in particular Simon de Lestang and Peter Stephenson, for their hard work and willingness to respond to Panel requests, and for their exceptional support, provisioning, and general hospitality during the review.

Overview

A key feature of the 2010 assessment model is that many parameters are still estimated using analyses undertaken outside of the assessment, often applying methods with quite different assumptions than those on which the assessment itself is based. This was also a key concern of the MSC auditors. The Panel recognised, however, that many of these external analyses were being undertaken as DoF scientists explored approaches through which parameters required by the model could be derived from the available data and, to some extent, the fact that these calculations were currently being undertaken outside the model reflected the stage of model development that had been reached. There are two problems that arise from setting the values for parameters using auxiliary analyses: (a) there may be bias if the assumptions of the auxiliary model used when calculating the values are sufficiently different from those of the model on which the assessment is based, such that the parameters do not have the same "meaning" in the two models, and (b) the ranges of uncertainty exhibited in the model projections do not represent the full range of parameter uncertainty. The ability to adequately quantify uncertainty is particularly important in the case of the WRLF because the decision rules make explicit reference to the probabilities of various states of nature.

The absence from the report for the 2010 stock assessment of details of the results of the sensitivity tests that had been undertaken by DoF scientists means that this assessment is unable to convey the full extent of uncertainty [in many cases, the uncertainty associated with the assumptions of an assessment will dominate that associated with parameter uncertainty].

The WRLF is data-rich with many data sets that have been maintained for a long time, including those arising from independent surveys of recruitment and abundance. Therefore, there would be considerable value in making greater use of these data when fitting the assessment model. Use of as many data sets as possible when fitting the model will also reduce the need to pre-specify parameters and hence provide a more accurate reflection of uncertainty.

The decision to manage the fishery using ITQs means that there is a requirement for the assessment model to provide better predictions of future recruitment and to estimate an appropriate level of catch to maintain egg production and achieve a target level of yield. Experiences in other fisheries have shown that the relationship between fishery-dependent indices of abundance and the true abundance changes substantially after introduction of ITQs thereby affecting the continuity of the data series (and their use in assessment). The Panel highlights that this means that future assessments will rely more heavily on the fishery-independent indices of abundance. This may require evaluating the design of the current data collection program and increasing its coverage to better monitor the fishery, particularly as the fishery transitions to an ITQ system.

Given the above, it was considered appropriate to look anew at the assessment model and the Panel therefore followed a two-pronged approach. The first element of this was to review the 2010 assessment, to undertake some basic changes to this model during the workshop and, through sensitivity tests, to explore the sensitivity of the model outputs to alternative assumptions. Such sensitivity analysis is likely to provide a better assessment of the robustness of the current management advice than diagnostic statistics of the base case alone. The second approach was to commence development of a modified form of the assessment that is directed more towards the

needs of an ITQ system with most of the parameters being estimated internally within the model. This will not only provide a framework to guide future work by the model developers, but also will address the MSC requirements more adequately and move the assessment towards an output-controlled management model.

Since the new ITQ model will require further development, and given the move to ITQs, the Panel **recommends** that a technical support structure for the assessment team be put in place, through:

1) setting up a committee based on the Commonwealth's Resource Assessment Group (RAG) structure that has membership of assessment staff, biologists, external modellers, managers and industry,

2) providing assessment staff with the resources and time needed for further model development as the new ITQ model still requires additional work,

3) the newly-established RAG providing clear guidance as to what the assessment document should contain and which sensitivity/diagnostic tests are required, and

4) developing a community of practice in the field of lobster stock assessment science, as the new ITQ model has a structure that is reasonably similar to that of other lobster models, e.g. for southern rock lobster, and greater communication among the different assessment scientists would assist model development.

A. The 2010 stock assessment model and parameter estimation

The population dynamics model on which the 2010 stock assessment was based and which was provided to the Panel at the start of the workshop was spatially- length-, and sex-structured. This type of model is appropriate for conducting stock assessments for species which cannot be aged, for which growth and selectivity differ among sexes and for which management advice is needed spatially. The Panel **concludes** that the basic model structure is appropriate.

Three key concerns of the Panel were: (a) the pre-specified parameters of the model should not be based on the same data that are then used to estimate the free parameters of the population dynamics model, (b) care should be taken not to make assumptions which artificially reduce the variances of the model predictions, given the inclusion of measures of precision in the decision rules, and (c) the model is very complicated (owing to the need to capture the many requirements of management), which may negatively impact on the ability to make inferences regarding, for example, stock status. Each of these issues is discussed in further detail below.

A.1 Basic model structure

The model is currently based on shallow and deepwater regions within 1° latitude transects, with regions within zone A being distinguished from those in zone B. The model operates on fortnightly time steps (although some of these are combined). The fortnightly time steps and spatial strata used in the model were selected to meet the needs of the management process rather than the nature and implications of the available data. The large number of time and spatial steps means that computer-time requirements for the assessment are substantial, which makes evaluation of sensitivity

difficult. Although managers' requirements are important, robust management advice can only be obtained by ensuring the model is of an appropriate complexity given the data. The Panel **recommends** that the spatial and temporal structure of the model be reviewed. Consideration needs to be given to management needs, but regions which exhibit similar trends in, for example, catch-rates and puerulus settlement rates should be pooled (see also Section A.3).

The Panel notes that each region contains only one "fleet" (catches by the commercial sector). An alternative model framework would be to have fewer regions, but more fleets within each region. There was insufficient time during the workshop to consider in detail whether such a change to model structure is appropriate, but moving to more fleets and fewer regions could lead to much faster run times (and hence the ability to explore more model configurations).

A.2 The inputs to the stock assessment

As noted above, the Panel **recommends as a high priority** that as many parameters as possible are estimated within the assessment rather than being based on auxiliary analyses. This is especially important because there are several occasions where the data had essentially been used twice: (a) as part of the auxiliary analyses and (b) when estimating the values for the other parameters of the model. This is inappropriate.

The Panel further **recommends** that all of the various data sources be examined and, to the extent possible, included in the assessment. In particular, the data from the fishery-independent surveys need to be post-stratified into the regions and time steps used in the model and included when fitting the model. Progress in this regard is documented in Appendix G.

A substantial amount of work is involved in converting the raw data collected from the fishery into the catch, effort and length-frequency inputs for the model. The Panel **recommends** that the process of data conversion be documented fully and a summary included within the assessment report. Similarly, the manner in which the annual efficiency increases are computed is not documented well. During the workshop, DoF staff prepared a document that showed how the annual catch efficiency was calculated. Based on this, and the Panel's reading of the report, aspects of efficiency relating to the effect on catch-rate within the fortnightly time steps used in the model, such as the effects of moon phase, swell, etc. do not appear to have been considered. A detailed description of the external analysis used to determine the effect of temperature on the catchability of the red lobsters has been reported by de Lestang et al. (2009), but details of this analysis are not included in the assessment report.

The Panel **recommends** that the relationship between catchability and length should be based on fitting a function to the estimates of fishing mortality by length-class derived from tagging data and not time-at-liberty.

A.3 Including spatial structure

The current model contains 14 regions, which leads to high data demands and adds substantially to run-times. This would also affect the ability to undertake extensive sensitivity tests within a reasonable time frame. While some spatial structuring is needed to meet management needs, the number of regions seems too high given the available data. The Panel reviewed trends in catch-rates among areas. Correlations among these data showed that it would possibly be appropriate to combine several of the adjoining regions within Zones B and C. Given the discussions with members of

staff from DoF, there may be a case for dividing Zone A further, to allow more explicit representation of the northern Abrolhos and Big Bank region, which appear to be of considerable importance as a source of egg production given the results of recent source-sink analyses.

The geographic boundaries/units of management appropriate for managing egg production levels are determined by an assessment of the risk to the population of failing to maintain the spatial distribution of egg production. An increased understanding of the source/sink relationships relating egg production to resultant settlement and of the inter-annual variability in the predicted geographic distribution of puerulus settlement is needed when assessing such risk. The Panel is not the appropriate group to assess the value of the egg production within each region, as this would be better addressed by DoF staff. The Panel notes that, as in other fisheries, it is considered appropriate to maintain egg production at appropriate levels throughout the range of the fishery. The Panel therefore endorses this management objective, which has been adopted for the WRLF. It would be useful to undertake a management strategy evaluation (MSE) to assess the implications to the sustainability of the stock of different geographic structures within the model under different hypotheses regarding the relationship between egg production and puerulus settlement.

Exploration of the implications of maintaining a more detailed spatial resolution versus combining regions within the model may be explored using a sensitivity analysis.

The Panel noted that the 2010 assessment model allowed for the migration that occurs between inshore and offshore regions within each zone and between the inshore regions of zone B and the offshore region of zone A. However, migration between zones C and A-B was not yet explicitly captured within the model (see Section A.1). However, simultaneous assessment of zones A, B, and C is currently constrained by the high computational demands associated with fitting the assessment model. Future analyses to take migration between these zones into account will require modification (simplification) of the model to enhance computational performance. Analyses of tagging data external to the model to explore the migration of lobsters are currently being undertaken by the DoF staff. Given recent levels of exploitation and the results of the recent analyses of tagging data, migration among regions and between zones has become an important issue that will need to be considered in future models. The Panel **recommends** that ultimately a single model that includes zones A, B and C and migration among the regions and zones be developed, but recognizes that this is a long-term goal.

A.4 Estimating parameters and the objective function

The draft description of the 2010 stock assessment model, which was provided to the reviewers, represented a work in progress as the timeline for the review was based on the conditions set by the MSC. As presented to the Panel, however, the document is inadequate. This limited the Panel's ability to fully review the assessment and required investigation of the code implementing the model and its associated estimation framework, as well as discussions with the modellers, to clarify aspects of the model structure. The assessment document is the primary mechanism through which the modellers communicate with managers, industry and other modellers and needs to follow a standard format and fully describe what is being done. Some guidance as to how to write an assessment document for size-based models has been

developed by the Crab Plan team of the North Pacific Fishery Management Council (http://www.fakr.noaa.gov/npfmc/membership/plan_teams/CPT/Appendix_CrabWKSHPreport909.pdf).

The Panel reviewed the objective function used in the version of the model presented initially. The objective function had three components:

(1) The catch (in weight) by region, time-step, and year

(2) The length-frequency of the catch by sex, region, time-step and year.

(3) A penalty on the difference between the recruitment deviations and anomalies derived from the externally-derived prediction model relating annual catch to puerulus settlement 2 years earlier (by region and year).

The Panel was concerned that the weighting factor applied to the catch likelihood was a mixture of observed and model derived values, that the likelihood for the length-frequency data was not weighted by an "effective" sample size[4], and that the weight assigned to the penalty of the recruitments only reflected sampling error (and not error related to the relationship between puerulus counts and recruitment at age 2). Given these concerns, the Panel **made the following observations and recommendations**:

(1) The arbitrary nature with which high catches are given extra emphasis in the catch component of the likelihood needs to be eliminated through use of an alternative, more conventional, weighting scheme (such as assuming that the square-root of catch is normally distributed – i.e. that the distribution of catches is approximately Poisson)[5]. The distribution of residuals needs to be examined to confirm that this transformation is appropriate.

(2) The length-frequency data are weighted by the actual sample sizes. This is likely to overweight these data. The Pearson residuals were examined during the workshop which suggested that the data were over weighted substantially relative to the fit of the model to the data. Future applications of the model should be based on setting the extent of overdispersion to an appropriate value.

(3) The CV used to weight the puerulus data in the likelihood only accounts for the sampling error for these data and not the uncertainty related to how well puerulus indices predict the true recruitment. An extra component of variance needs to be included in the model to account for this in this component of the likelihood function.

(4) The use of a robustified likelihood function for the indices and the compositional information should be considered.

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[4] The "effective sample size" is the sample size of a random sample that produces estimates with the same precision as those obtained from the observed sample, which is typically collected according to a specified, often clustered, sampling scheme.

[5] The new ITQ model (Appendix G) already incorporates these recommendations.

(5) Effective sample sizes should be computed using the data on length-frequency (by vessel / trip). The weights assigned to the length-frequency data in future need to reflect these "effective" sample sizes.

(6) The code should be modified to allow the weights assigned to each likelihood components to be modified so that inconsistencies between the information contained in the different data sets can be identified[3].

The Panel reviewed all available data sources as well as the values for parameters which are pre-specified. Based on this review the Panel **makes the following recommendations**:

(1) The data from the IBSS (catch-rates and length-frequency data by region and sex) need to be included in the objective function[3].

(2) The parameters which are pre-specified should not be based on the same data that are included in the assessment. In this regard, the Panel **recommends** that the following parameters should not be pre-specified but rather estimated during the model-fitting process (α_r - the parameter which determines the extent of non-linearity in the relationship between puerulus and recruitment; the efficiency increase parameter vector for each zone/region; the parameters of the relationship between temperature and catchability; and the parameter which determines the impact of the environment on catch-rates during 2009/10). The migration parameters are currently informed guesses. Ultimately, the tagging data should be included formally in the assessment and migration estimated.

(3) The average recruitment for each region should be treated as an estimable parameter [rather than as average recruitments and proportions recruiting inshore and offshore] [3].

(4) The initial state of the model should be estimated rather than being pre-specified using the results of an old version of the model. Pre-specifying the initial state using predictions for the 1980s is both inappropriate statistically, reduces the variances of the final outputs, and leads to anomalous behaviour when some of the pre-specified parameters are changed.

(5) The independent sampling of the fishery that is currently undertaken should be reviewed in the context of the move to ITQ as many of the present surveys were designed for a different purpose.

The description of the 2010 model in the assessment report needs to be refined. A table describing the notation used should be included. Associated with these parameters should be a column(s) describing whether they are estimated; and the parameter value and source if they are an input. The order of presentation and layout of the description should be modified to enhance understanding of the sequence in which the calculations are undertaken (see, for example, the structure in Appendix G). A description of the method by which system state is initialised needs to be provided.

A.5 Diagnostic statistics

The version of the assessment initially presented to the Panel had limited diagnostic information. The Panel highlights that guidelines exist for diagnostic statistics for size-structured stock assessments (e.g. http://www.fakr.noaa.gov/npfmc/membership/plan_teams/CPT/Appendix_CrabWKSHPreport909.pdf) and that examination of diagnostic statistics (along with the results of alternative [plausible] model scenarios) is the standard way to evaluate model robustness. Alternative model scenarios should be developed and compared with the results of the base case model to explore the sensitivity of the model outputs to the various assumptions.

Several diagnostic statistics were provided to the Panel during the workshop. These included the residuals about the fit to catches as well as the Pearson residuals for the size frequency data collected during the commercial catch observer program. These, particularly the latter, showed non-random patterns. For example, there was a clear structural bias with consistent patterns of over- and under-estimation in different size ranges. This could be a feature of mis-specified (especially input) parameters and possibly the complexity of the model. This inconsistency was also exhibited by the more recent data, suggesting that the projected values are likely to be affected, which could lead to a bias in the predictions of egg production. The catch rate residuals are mixed in that the fits are reasonable for some regions whereas they are consistently not in others (e.g. region 10). This may reflect the lack of data in region 10 and possibly points to the need to pool regions.

A.6 Sensitivity tests

Sensitivity analyses requested by the Panel were run by the assessment team using the slightly modified version of the 2010 assessment model, i.e. not the ITQ model. The results of these sensitivity analyses demonstrated the marked influence of the initial state used in this model, and that of natural mortality. In the latter case, the response appeared contrary to expectation. This should be investigated further when sensitivity tests are undertaken of the new ITQ model.

B. Using the stock assessment to make predictions on which management advice is based.

The assessment is structured so that it can provide the input required by the decision rules. The Panel notes that the assessment framework in Appendix G addresses many of the concerns outlined above and **recommends** that, after careful review by the assessors, this new ITQ model should form the basis for future assessments.

Many management questions are difficult to address using a stock assessment model alone. This is because a stock assessment model cannot address what, for example, would be the long-term effect on the sustainability of the resource of mis-specifying aspects of the model and thus failing to provide an adequate representation of what is likely to be occurring in reality. The only way to assess the implications of such mis-specification is through the development of a MSE framework. The MSE approach distinguishes between the true state of the resource (as represented by an 'operating model') and that perceived though data collection strategies and stock assessments (a component of the 'management strategy'). The management strategy includes not only an assessment procedure, but also any decision rules that use information on the perception of the status of the system to determine management advice. The management advice determines the management actions and hence any

impacts these actions have on the resource and the associated fishery. The MSE approach therefore attempts to consider the whole management system. Representation of uncertainty is a key component of the MSE approach, and the impact of several sources of uncertainty can be evaluated. It is therefore only this tool that can truly assess whether the assessment provides robust advice. It should be noted, however, that implementing an MSE is time consuming. Another requirement for the development of an MSE is that the assessment model must be able to be run within reasonable time frames because an MSE tends to involve running the assessment model many times. For this reason, and also to assist when undertaking standard sensitivity tests, the model was streamlined during the review and now runs substantially faster.

Finally, the model should be modified to allow for the types of data that will become available after the introduction of ITQs, and needs to allow for the possibility that both fishery catchability and selectivity/vulnerability of the different size classes will be affected by this management change.

C. The framework for a bio-economic model and the harvest strategy

There is a trade-off between management complexity and the extent to which a full dynamic bio-economic model should be implemented. A fully specified bio-economic model requires a well-understood (in terms of sensitivity) stock assessment model, present cost and price parameters, a well-specified profit function that restricts volatility, and also reliable projections of future key cost and price parameters.

The Panel did not review the decision rules as the selection of thresholds and targets reflect policy, rather than scientific, considerations. Nevertheless, the structure of the decision rules (which include threshold and limit values as well as penalties for increased uncertainty) is consistent with world's best practice. The use of the decision rules relies on the outputs from the assessment and, in this respect, the Panel **reiterates** its comments that the current assessment probably under-estimates the true extent of uncertainty. This can be addressed by either capturing more sources of uncertainty in the assessment or by specifying the sources of uncertainty to which the probabilities in the decision rules relate.

The Panel r**ecommends** that a target reference point is specified within the present harvest strategy. It is further **recommended** at this stage that a harvest rate (or an egg production level that would be expected to result from this harvest rate) representing a proxy for MEY be developed. It is **not recommended** that a full dynamic MEY system is implemented yet given the changes to the fishery as a consequence of the introduction of ITQs in the next few years and the current stage of development of the assessment model. However, the new ITQ model in Appendix G is coded in a way that could be readily adapted to account for bio-economic considerations. The Panel **recommends** that the decision rules be extended to include a recovery strategy.

D. The causes for the low puerulus settlement

The current model structure does not explicitly include the processes that represent the alternative hypotheses which have been proposed as the causes of recent low puerulus settlement. It is thus not possible to use the stock assessment model to assess which of these hypotheses has highest probability. Consideration of the possible relationships between egg production and puerulus settlements in different regions could be explored by extending the assessment model, which currently considers

puerulus settlement to be related only to environmental factors, to include a formal stock-recruitment relationship.

The Panel also **recommends** that an MSE be developed to explore the robustness of the management strategy (which includes the system of data collection, the assessment model, and the decision rules) to different hypotheses regarding future recruitment success.

E. Response to MSC concerns

Condition 1.1.1.5:

The catch, effort, and length-composition data used in calculating indices of egg production are now used as input to the new ITQ model, which is fitted to the resulting catch and length frequency data. Fitting indices of egg production would be redundant and inappropriate because the data used to calculate those indices are already included in the catch and length composition likelihood components of the objective function. Calculations of egg production in the model consider externally-derived trends in size at maturity and calculations of catch rate consider externally-derived changes in catchability in response to temperature. These external calculations need to be undertaken within the model (to the extent feasible) to fully reflect the uncertainty they contribute to the assessment outcomes. The stock assessment report will need to be revised to describe the new model structure.

Condition 1.1.4.2:

The draft harvest strategy has been distributed for public comment, but the recent decision by the Minister that the fishery is to move to an ITQ-based management regime and adopt an MEY-based objective will require that the proposed harvest strategy be reconsidered. In particular, there is now an urgent need to incorporate a target reference point and decision rule to be used when determining the TACC.

Condition 1.1.4.4:

The Harvest Strategy discussion paper has not clarified what is intended by the elements of the decision rules that require a review to be undertaken, such that there is confidence that this measure will determine the most effective form of management response, within reasonable time frames. The Panel recommended that the decision rules should specify a clearly-defined response.

Condition 1.1.5.1:

An international peer review of the 2010 stock assessment has been undertaken at this workshop and, in collaboration with members of the Panel, a model that should provide a more robust assessment of the stock, i.e. the new ITQ model, has been initiated. In particular, with respect to the following model requirements specified by the MSC:

- *Estimating depletion within the model by fitting to seasonal trends in catch rates*

  The 2010 stock assessment and new ITQ models are fitted to the time series of fortnightly catches within each area, thereby using information on within-season depletion when estimating parameters.

- *Reintroducing breeding stock indices into the objective function*

Catch, effort and length composition data from the Independent Breeding Stock Surveys are now included in the objective function of the new ITQ model. Inclusion of breeding stock indices in the objective function would be inappropriate as this would re-use data that are currently employed in the likelihood components for catch and length composition.

- *Estimating efficiency change within the assessment model.*

  The Panel recommended that the calculations of efficiency for the post 1990/91 period be undertaken within the model.

- *Identifying key uncertainties in assumptions and data and undertaking appropriate sensitivity analyses*

  Several of the major sources of uncertainty are now considered in the new ITQ model. The Panel recommended that other sources of uncertainty should be identified and appropriate sensitivity analyses undertaken and reported.

  - *Estimating the relationship between puerulus settlement and recruitment within the assessment model*

  The new ITQ model now includes this relationship in the objective function in an appropriate manner, allowing observed values of puerulus settlement to inform the estimates of resultant associated recruitment.

  - *Incorporating size data into the assessment*

  The new ITQ model now includes the contribution of length-frequency data (commercial and IBSS) to the objective function in a more appropriate way. The Panel has recommended, however, that estimates of effective sample size should be determined and included in the likelihood function.

Condition 1.1.5.2:

While the 2010 stock assessment considered changes in the efficiency of effort, and changes in maturity and catchability affecting breeding stock indices, the confidence bounds presented in the report of this assessment underestimated the true level of uncertainty. Some aspects of the model that resulted in such underestimation have been addressed in the new ITQ model, e.g. through introduction of an improved method to determine the initial system state, and improved methods to project the model forward allowing for uncertainty in the final system state and in projections. The Panel recommended that calculations undertaken outside the model be made within the assessment (where feasible and efficient) and that sensitivity analyses be undertaken and reported to provide an evaluation of the uncertainty associated with model structure and data inputs.

Condition 1.1.5.3:

The Panel recommended the development and reporting of a base-case model with comprehensive diagnostics, and explicit reporting of the results of sensitivity runs for alternative cases.

Condition 1.1.5.5:

The Panel recommended that, after the development of an assessment model (based on the model framework for the ITQ model, which was developed during this workshop) has been completed, a management strategy evaluation should be undertaken to assess the effectiveness of alternative decision rules and explore the

robustness of these decision rules to alternative hypotheses relating to the possible causes of the recent decline in puerulus settlement.

F. Summary of Recommendations

In addition to the various recommendations listed above, a number of which were addressed in revising the model during the workshop, and some of which are repeated below, the Panel **recommends** that, in the short term (e.g. by the end of 2010) and in order of priority, the following actions be undertaken:

1. The assessment team should critically examine the new data inputs and ADMB code for the new ITQ model to verify that the intended revised model structure is correctly implemented. This is likely to be facilitated by revising the mathematical description that summarises the equations (Appendix G) that are implemented in the revised ADMB code. Errors that are detected should be corrected.
2. The assessment team should confirm that, when using different initial values of parameters, the new ITQ model converges to the same parameter estimates, e.g. through a jitter analysis. Details of the analysis and the results should be documented. Problems in obtaining convergence should be addressed.
3. Computer software should be developed to automate the production of detailed and complete model and diagnostic outputs, e.g. tables of indicator variables and reference points, plots of predicted versus observed values, results of residual analysis, bubble plots of Pearson residuals for length composition data, etc. Such software will assist in reporting the details of the assessment and the results and will facilitate evaluation of the model's integrity.
4. The assessment team should identify key indicator variables and reference points that should be considered when comparing the results of sensitivity tests and which will be required by the decision rules and by managers and fishers seeking to assess the management implications of model results. These indicator variables will include results of model projections. If necessary, the ADMB code should be modified to calculate and output the required statistics.
5. The revised model should be run, with the results being accepted as the current base case. Details of the analysis, the parameter estimates, asymptotic standard errors, parameter correlation matrix, and detailed diagnostic outputs should be documented and examined. Errors detected in the results should be resolved by correcting the code and the model description. The assumptions of the model may need to be modified and a new base case generated if the diagnostics identify a major structural uncertainty with the model. Sensitivity analyses identified below may assist in determining how the model may need to be restructured.
6. The assessment team should develop an explicit list of key uncertainties in model assumptions that reflect uncertainties in model structure and that should be considered as alternative cases. A critical assessment of the diagnostic outputs for the base case model is likely to assist in identifying aspects of the model requiring exploration though sensitivity tests.
7. The model should be re-run to explore the sensitivity of results to each of the alternative model cases. Results of the alternative models should be compared with the results from the base case model. The contributions of components to the likelihood should be used to develop likelihood profiles for selected key input parameters, such as natural mortality.
8. Results of the above analyses should be critically assessed to determine whether the results from the base case model are appropriate for determining the status of the fishery and advising on the appropriateness of alternative management

strategies. The results of the diagnostic plots will be crucial for this assessment, and may identify deficiencies in model structure that must be addressed before model results can be considered reliable (see Point 5, above). The results from the sensitivity runs should be used to provide information on the uncertainty of the results associated with model structure and data inputs if the base-case model is considered acceptable. The results of this assessment should be documented.

9. The current value of a target reference point, based on current and projected costs and prices and using an egg production or harvest rate proxy to an "equilibrium" MEY level, should be determined for use in the decision rules to be applied to the fishery.
10. The results of the base case model, and the alternative models, should be considered in the context of the decision rules for the fishery to determine whether the current management regime adopted for the fishery is adequate to maintain the egg production of the stock at a level consistent with the requirements of the decision rules, and likely to be consistent with regulations required to attain the target reference point.
11. A more detailed and clearer description of the model should be published.
12. To reduce model dimensionality, the model should be further revised to merge the regions that, on the basis of correlations among regions of, for example, catch-rates and puerulus settlement data, appear to be candidates for combination. Model results before and after merging regions should be compared to determine whether the simplified model improves the robustness of the results and to confirm that the model revision has had no unintended consequences.
13. A version control system, such as TortoiseSVN, should be implemented.

The Panel further **recommends** that, in the longer term and in order of priority, the following actions be undertaken:

1. A Research Assessment Group (RAG) should be established to ensure ongoing review of stock assessments and collaboration with rock lobster scientists from other states, many of whom are using or developing similar models for lobster fisheries.
2. The data sources used in the model should be examined to determine whether all data sources that are available are currently being utilised and, if so, whether such use is internal or external to the model. If external, consideration should be given to undertaking the analyses within the model and thereby taking the uncertainty associated with such analyses into account. As many parameters as possible should be estimated within the model. In particular, estimates of annual increases in efficiency since 1990/91 should be determined within the model.
3. The relationship between catchability and length should be based on fitting a function to the estimates of fishing mortality by length class. Alternative functional forms should be considered as sensitivity cases.
4. Estimates of effective sample size should be obtained and included in the calculation of the likelihood of the length composition samples.
5. Use of robustified versions of likelihood functions should be considered.
6. A detailed description of the methods used to convert raw data to the data that are input to the model should be produced.
7. The length bin structure is specified as an input to the model. The model should be modified to allow for a more flexible length bin structure to further reduce model's dimensionality. Length bins could be defined at run-time and with the code automatically reconfiguring the data to fit the specified length bin structure. Sensitivity runs should be undertaken to determine whether a simplified length

composition structure with fewer bins would produce results consistent with those obtained using the current number of length bins.

8. The impact on management advice of reducing the number of spatial cells considered within the model through introduction of a "fleet" concept employing different selectivity patterns for different fleets should be considered, and an assessment made of whether such a simplified model should be adopted in place of some aspects of the more complex model.
9. The existing models should be combined to form a single model that includes all regions within all zones, i.e. A, B, and C.
10. The model (for the entire fishery) should be extended to include migration among regions and zones using estimates of parameters relating to migration derived (internally) from tagging data.
11. An MSE should be developed, and the effectiveness of alternative decision rules, and the robustness of these decision rules under the alternative hypotheses relating to the cause of the recent decline in puerulus settlement, should be explored. For example, an MSE could be used to assess whether it is more effective to use a four or five year projection period for the decision rule requiring that, for each year of this period, the probability of predicted annual egg production being greater than the threshold exceeds 70%.

References

de Lestang, S., Caputi, N., and Melville-Smith, R. 2009. Using fine-scale catch predictions to examine spatial variation in growth and catchability of *Panulirus cygnus* along the west coast of Australia. *New Zealand Journal of Marine and Freshwater Research*, **43**: 443–455.

APPENDIX A

RELEVANT AUDIT CONDITIONS SET BY THE MARINE STEWARDSHIP COUNCIL'S AUDITORS

Background

In March 2000 an industry lead initiative resulted in the Western Australia Rock Lobster Fishery (WRLF) becoming the first fishery in the world to be certified by the Marine Stewardship Council (MSC). In December 2006 the WRLF was successfully re-certified by Scientific Certification Systems (SCS) for a further five years (i.e. until Nov 2011). The MSC certification process is considered to be the most rigorous and comprehensive independent fisheries assessment in the world and the WRLF has demonstrated strong leadership in its willingness to embrace this rigorous and transparent process that covers stock assessment, effects of fishing on the ecology and management practices and governance. Many of the certification conditions set by the SCS/MSC are also requirements for export approval under the Commonwealth Government's *Environment Protection & Biodiversity Conservation Act 1999* (*EPBC* Act – ecologically sustainable fisheries legislation).

The Western Rock Lobster Council (WRLC) is the Client for the certification of the western rock lobster fishery (WRLF) by the Marine Stewardship Council (MSC) and the cost is recouped from the commercial industry via a cost recovery process. The Department of Fisheries (DoF), as the management authority and major research provider, plays a crucial role in facilitating the certification process.

The MSC's independent certification body (CB), Scientific Certification Systems, undertook the annual audit of the fishery and a special audit of Principle 1 (P1) – Stock Assessment, in November 2009. The special P1 audit was conducted due to concern regarding the very low puerulus settlements that occurred in 2007/8, 2008/9 and more recently in 2009/10 and how they would impact on the breeding stock and hence the long term sustainability of the fishery. SCS set a number of conditions for ongoing certification under Principle 1, Principle 2 – Effects of Fishing and Principle 3 – Governance.

Following a meeting between the WRLC and DoF regarding the conditions set by SCS's auditors on Tuesday 10 February 2010, the draft Action Plan below was developed.

Full details, of SCS's November 2009 surveillance report can be found on the MSC's website at: http://www.msc.org/track-a-fishery/certified/south-atlantic-indian-ocean/western-australia-rock-lobster/reassessment-downloads-1

Set out of the Action Plan

The condition set by SCS is shown in yellow.

Principle 1 – Stock Assessment

Most of the conditions set for Principle 1 would have been done as part of the normal stock assessment and modelling review / development process. The stock assessment group appear to have most of them in-hand.

Condition 1.1.1.5 (2009):

The client shall provide to the CB a report showing how current major uncertainties in BSS and IBSS indices, including changes in maturity and environmentally induced inter-annual changes in catchability, have been addressed. The report will include revised time series for estimates of breeding stock, including confidence bounds and the way that they reflect the uncertainties in the analyses. The report shall be reviewed as part of the international review of the stock assessment (see indicator 1.1.5.1) and the reviewed and agreed time series will then be used in the quantitative stock assessment.

Condition 1.1.4.2 (2009):

The Client shall provide the CB with clear evidence that the interim harvest strategy and decision rules applied for the 2009/10 fishing season, and intended to be applied for future management of the fishery, have been **formally endorsed by the Minister** and made publicly available.

Condition 1.1.4.4 (2009):

Issue a clarification of what is intended by the elements in the harvest strategy that involve undertaking a review, such that there is confidence that this measure will not be used to delay appropriate management responses, but instead be used to determine the most effective form of management response, within reasonable time frames.

Condition 1.1.5.1 (2009): *(This condition also applies to indicators 1.1.2.2, 1.1.5.2 & 1.1.5.5)*

Undertake an international peer review of the current (2009) stock assessment and work with the peer reviewer(s) to develop a robust assessment of the stock. Issues to be addressed include:

- Estimating depletion within the model by fitting to seasonal trends in catch rates
- Reintroducing breeding stock indices into the objective function (after the condition for indicator 1.1.1.5 is met)
- Estimating efficiency change within the assessment model
- Identifying key uncertainties in assumptions and data and undertaking appropriate sensitivity analyses

Issues to be considered include:

- Estimating the relationship between puerulus settlement and recruitment within the assessment model
- Incorporating size data into the assessment

The client shall than provide a report to SCS of the outcome of the review, including an updated 2009 quantitative stock assessment report, based on recommendations and findings of the review. Assuming a satisfactory resolution of the current uncertainties and problems in the assessment, the new assessment model would then be used as the basis for the 2010 assessment and for the provision of management advice for the 2010/11 fishing season.

Condition 1.1.5.2

Revised Rationale: While there is considerable exploration and analysis of uncertainties in data and parameters in the background information on the assessment (Caputi et al 2009), few of these are properly reflected in the quantitative assessment (Stephenson and de Lestang 2009). The exception is uncertainty about future recruitment arising from the collapse in puerulus settlement, which is dealt with in the projections but does not (yet) impact on the assessment of current resource (breeding stock) status. As noted elsewhere in this report, key uncertainties that should be dealt with include changes in efficiency of effort, and changes in maturity and catchability affecting breeding stock indices. The confidence bounds presented in the assessment report do not adequately reflect (underestimate) the true level of uncertainty in the assessment. Overall, the fishery meets the 60 scoring guidepost, and the second element of the 80 scoring guidepost (to the extent that uncertainty about puerulus settlement is dealt with).

Condition 1.1.5.1 (2009) above should address the uncertainty in the assessment.

Condition 1.1.5.3 (2009): All future advice by management to RLIAC, the Minister, and stakeholders must include as a routine feature, "best estimates" of stock status and a forecast of effects of management arrangements. At the same time, the advice must also provide a clear indication of the major uncertainties in current assessments and projections. (See Condition to indicator 1.1.5.1).

Progress on this Condition will be determined at the next annual audit as it is only possible to judge at the time major (annual) management decisions are made.

Condition 1.1.5.5

Revised Rationale: The model used for the quantitative assessment of the western rock lobster provides a good basis for evaluating different management options for the fishery and has clearly been useful (and used) to explore combinations of tactical measures to achieve desired catch reductions in the face of concerns about puerulus settlement. However the concerns discussed above about the robustness of the current quantitative assessment also raise concerns about the robustness of the forecasts and do not currently support a high degree of confidence in the adequacy of the harvest evaluation. This indicator clearly meets the first element of the 60 scoring guideline

and also meets the second element in the sense that the exploration of management tactics is probably robust to the uncertainties in the assessment.

APPENDIX B
QUESTIONS POSED BY DR RICK FLETCHER

A. Units of Management and Decision-rule framework

1. What are your opinions on the most appropriateness of the current geographic boundaries/units of management that are used to monitor and manage egg production levels? (*See Section A.3*)

2. Should alternative geographical divisions be considered (noting that licenses are currently linked to individual zones)? (*Yes, Section A.3 outlines some possible ways to select geographic areas in a formal and replicable manner*)

3. What is the relative robustness of using the current decision rules that use the current threshold levels of egg production in each zone, the degree of certainty required (currently > 75%) and the time scale (currently 5 years in advance)? (*The Panel did not have information to evaluate the relative robustness of the decision rules; Section B outlines an analytical framework for addressing this question*)

4. Is this set of rules affected by the shift to quotas, the additional information available on source sink, recent recruitment levels and migration levels, plus any potential change in management units (see previous point)? If so how to move forward? (*The Panel did not have information to address this question*)

5. Can the review team provide any option(s)/opinions for efficiently determining a target level for each zone (or the entire fishery) that could result in an Annual MEY (recognising that the recruitment costs, prices will to vary annually) level of catch. For example, what would be the implications (or how would these be determined) of using a target level of egg production in each zone that is consistent with an average MEY level of harvest? (*Comments on implementing an MEY policy are included in Section C*)

B. Model Inputs

1. Are the changes in S@M now appropriately included in the model? (*Yes, these data are included in the model and are used when conducting forecasts*)

2. Are the changes in fishing efficiency now appropriately included in the model? (*Yes, but see Section A.2*)

3. Are the uncertainties in inputs included appropriately in the model? (*Some uncertainties are accounted for, but this is incomplete; See Section A.2 and A.4)*

4. Is the method for estimating depletion within the model by fitting to seasonal trends in catch rates now sufficiently robust (*Generally yes; however, insufficient testing has been conducted to fully evaluate the robustness of the current assessment approach*).

5. Is the method for inputting the relationship between puerulus settlement and recruitment (based on a relationship estimated outside the model) into the assessment model acceptable. (*No, the Panel recommends estimating the relationship within the model Section A.4*)

6. Has the lobster size frequency data now been incorporated appropriately into the assessment (*Generally; the Panel has concerns with how these data are weighted; Section A.4*)

C. Model Structure

1. What process (or options) should be used to most efficiently include the IBSS indices (including their measurement uncertainties and the impacts of environmental conditions) within the objective function? (*See Section A.4*)

2. What is their opinion on what future value there will be in the fishery-dependent BSI? (*These data will have a much larger impact on assessment results once the length of time-series is greater and particularly if the relationship between catch-rates and abundance changes*)

3. What opinions do the review team have on the most efficient structure for the model in terms of spatial units, length bins and time steps to deal with the shift to quota based management, and targeting MEY levels, including steps to determine this. (*The Panel did not explicitly address this questions; relevant information is provided in Section A.3*)

4. Is the model structure more or less likely to easily link to the bio-economic modelling that is proposed? (*The Panel knows of no reasons why a finalized model could not be linked to a bio-economic model although it is concerned about the complexity of the model limiting the ability to explore strategies*).

C. Quota Assessment Method

1. With what confidence is the current or revised model likely to provide robust projections for egg production into the future that would enable proposed management settings (quota and other measures) to be examined? (*The Panel cannot assign a level of confidence to the predictions owing to the lack of a full suite of diagnostics and sensitivity tests*).

2. What would be the stock implications for the quota being set as one integrated figure and allocated to the different zones compared to being set 'separately' for each management unit/zone. (*This issue should be addressed using an MSE; Section B*)

D. Harvest Strategy Decision Rules

1. What advice can be provided for moving this current framework from one that was based on input controls and largely MSY based settings, to a quota targeting MEY based principles? (*The Panel did not have sufficient time to discuss this issue but it should be relatively straightforward*)

2. Have the uncertainties associated with the cause of the low puerulus been sufficiently covered by the model and the associated harvest strategy/ decision rules framework (*See Section D*)

APPENDIX C

DRAFT WORKSHOP AGENDA

Day 1 – Thursday 20 May 2010

9-12	Model discussions with Cathy, Norm, Klaas	
12:00	Lunch	
1:00	Welcome	R Fletcher
1:15	Objectives of workshop	R Brown
1:30	Breeding stock	S de Lestang
2:00	Model description	P Stephenson/S de Lestang
3:00	Break	
3:30	Stock assessment 2009-2010	S de Lestang
4:00	Harvest strategy and decision rules	K Donohue
4:30	Environment effects on puerulus, migration	N Caputi/S de Lestang
5:00	Refreshments	

Day 2 – Friday 21 May 2010

- 2009 stock assessment review (one or two hours?) if not already done on Thursday.
- Modelling group[6] to work on model
- Late afternoon – bio-economic model discussions

Day 3 – Saturday 22 May 2010

- Modelling group / individuals to work on model

Day 4 – Sunday 23 May 2010

- Morning – report writing?
- Afternoon – social event (late lunch?) with room to talk shop informally.

Day 5 – Monday 24 May 2010

- Morning – assessment of the progress made to meet of Marine Stewardship Council auditors conditions:
    - model
    - 2009 stock assessment
    - Harvest Strategy and Decision Rules

- 3-5 pm – presentation and discussion of recommendations:

[6] Modelling group – Andre, Norm, Cathy, Peter, Simon and Nick

- Welcome (R Fletcher)
- Overview of process (R Brown)
- Andre, Cathy and Norm:
  - breeding stock
  - stock assessment model
  - 2009 stock assessment
  - Harvest Strategy and Decision Rules
  - factors that may be contributing to the low puerulus settlement
  - bio-economic model
  - other issues

APPENDIX D

WORKSHOP PARTICIPANTS

Department of Fisheries

Rick Fletcher
Peter Stephenson
Nick Caputi
Simon de Lestang
Rhys Brown
Jason How
Adrian Thomson
Dan Gaughan
Brent Wise
Lynda Bellchambers
Rod Lenanton
Eva Lai
Anthony Hart
Matt Pember
Brett Molony
Arani Chandrapavan
Eric Barker
Mark Rossbach
Mervi Kangas
Jo Kennedy
Kevin Donohue
Phil Unsworth

External

Norm Hall
Klaas Hartmann
Andre Punt
Cathy Dichmont
Kim Ley Cooper

Industry / Stakeholders

Dexter Davis

Ron Maloney
Garry Coleman
Anthony Santaromita
Mark
Jennifer Maloney
John Cole
John Newby
Terry Lissiman
Gil Waller
Clinton Moss
Fedele Camarda
Peter Prido

APPENDIX E

DOCUMENTS PROVIDED TO THE PANEL

Anonymous. 2008. *Western Rock Lobster Stock Assessment and Harvest Strategy Workshop 16 – 20 July 2007 Western Australian Fisheries and Marine Research Laboratories*. Department of Fisheries Western Australia. Fisheries Occasional Publication No. 50.

Brown, R. 2009. *Western Rock Lobster Low Puerulus Settlement Risk Assessment Workshop Held 1 and 2 April 2009*. Western Australian Department of Fisheries, 3rd Floor The Atrium, 168 St Georges Terrace, Perth, Western Australia, 6000.

Caputi, N., Melville-Smith, R., de Lestang, S., How, J., Thomson, A., Stephenson, P., Wright, I., and Donohue, K. 2010. *Stock Assessment for the West Coast Rock Lobster Fishery*. Pre-dissemination draft document provided to Review Panel for the sole purpose of reviewing the stock assessment.

Donohue, K., Caputi, N., de Lestang, S., Brown, R., and Fletcher, W. 2010. *Western Rock Lobster Fishery – Harvest Strategy and Decision Rules Proposals*. Western Australian Department of Fisheries, 3rd Floor The Atrium, 168 St Georges Terrace, Perth, Western Australia, 6000.

Fletcher, W.J. and Santoro, K. (eds). 2009. State of the Fisheries Report 2008/09. Department of Fisheries, Western Australia.

Smith, T., Ward, T., Phillips, B., Daume, S., and Swecker, J. 2009. Western Australia Rock Lobster Fishery 2009 MSC Special/Surveillance Audit Report. Scientific Certification Systems, 2200 Powell Street, Suite 725, Emeryville, CA 94608, USA

State of Fishery Reports

State of the Fishery Reports for the financial years 1998/99 to 2008/09 were available from http://www.fish.wa.gov.au/docs/sof/index.php?0706.

APPENDIX F

PANEL BIOGRAPHIES

Cathy Dichmont is Principal Research scientist in CSIRO Marine and Atmospheric Research, Brisbane. She received her B.Sc. in Zoology and Botany, and M.Sc. in Resource Modelling at the University of Cape Town, South Africa. She subsequently received her Ph.D. in Mathematics at the University of Tasmania, Australia. She has been a resource modeller at the Sea Fisheries Research Institute, South Africa, Queensland Department of Primary Industries, Brisbane, and in her present position in CSIRO. Her research interest include the development and implementation of fisheries stock assessment, bio-economic modelling, the evaluation of the evaluation of the performance of stock assessment methods and harvest control rules using the Management Strategy Evaluation approach, as well as recently into Multiple Use Management and the modelling human behaviour in fisheries. She has undertaken fisheries modelling in both data poor and rich situations. She has published over 40 papers in the peer-reviewed literature, along with 70 technical reports. She is currently the science member of the Northern Prawn Management Advisory Committee and the NPF Resource Assessment Group, as well as a member of the Queensland Trawl Technical Advisory Group. She also is the Chair of the NPF Research and Environment Committee.

Norman Hall is an Emeritus Professor in the Centre for Fish and Fisheries Research at Murdoch University, Western Australia, and currently is employed in a part-time position at the Western Australian Department of Fisheries (DoF) to undertake research on the collection and analysis of recreational fishery data. He received his B.Sc in Mathematics at the University of Western Australia, and his PhD in the field of Fisheries Science from Murdoch University. Between 1969 and 2000, he was employed by DoF, working in the fishery modelling and stock assessment field, during which time he was involved in the development of earlier models of the Western Rock Lobster fishery. Note that, in accepting the task of participating in this current review of the 2010 Western Rock Lobster assessment, Dr Hall alerted the organisers to his connection to the Department and the potential that he might be perceived as having a slight conflict of interest. In 2001, Dr Hall took up a position at Murdoch University, continuing his research in field of fishery population dynamics and modelling, before retiring in 2008. His research at the University continued in his role as an Emeritus Professor. He has published over 30 papers in the peer-reviewed literature, along with numerous technical reports. He is currently a member of the Northern Prawn Research Assessment Group.

André E. Punt is a Professor of Aquatic and Fishery Sciences at the University Washington, Seattle. He received his B.Sc, M.Sc and Ph.D. in Applied Mathematics at the University of Cape Town, South Africa. Before joining the University of Washington, Dr Punt was a Principal Research Scientist with the CSIRO Division of Marine and Atmospheric Research. His research interests include the development and application of fisheries stock assessment techniques, bio-economic modelling, and the evaluation of the performance of stock assessment methods and harvest control rules using the Management Strategy Evaluation approach. He has published over 160 papers in the peer-reviewed literature, along with over 400 technical reports. Dr Punt is currently a member of the Scientific and Statistical Committee of the

Pacific Fishery Management Council, the Crab PLAN Team of the North Pacific Fishery Management Council, and the Scientific Committee of the International Whaling Commission.

APPENDIX G

DESCRIPTION OF THE MODEL DEVELOPED DURING THE WORKSHOP

A. Basic dynamics

Changes in the number of animals of sex *s* in length-class *L* in region *r*, at the start of time-step *t* of year *y*, $N^s_{r,y,t,l}$, are due to growth, movement and mortality. The order of events during each time-step are growth, movement then mortality (although growth and movement do not occur in each time-step). The number of animals after growth and recruitment during time-step *t* of year *y* is given by:

$$\tilde{N}^s_{r,y,t,L} = \begin{cases} \sum_{L'} G^s_{r,L',L}\, N^s_{r,y,t,L'} + R_r \phi_L e^{\varepsilon_{\tilde{r}(r),y}} & \text{if } t = 1 \\ \sum_{L'} G^s_{r,L',L}\, N^s_{r,y,t,L'} & \text{otherwise} \end{cases} \quad (1)$$

where $G^s_{r,L',L}$ is the probability of an animal of sex *s* in region *r* growing from length-class *L'* to length-class *L*, R_r is the average recruitment to region *r*, ϕ_L is the proportion of the annual recruitment which recruits to length-class *L*, $\varepsilon_{\tilde{r},y}$ is the recruitment residual for transect $\tilde{r}$ and year *y*, and $\tilde{r}(r)$ is the 1^0 longitude transect in which region *r* is found

The number of animals after movement during time-step *t* of year *y* is then given by:

$$\tilde{\tilde{N}}^s_{r,y,t,L} = \begin{cases} \tilde{N}^s_{r,y,t,L}(1-\lambda_{\tilde{r}(r)}\Lambda^s_{r,y,t,L}) & \text{if } r \text{ is source region} \\ \tilde{N}^s_{r,y,t,L} + \sum_{r' \neq r} v_{r',r}\tilde{N}^s_{r',y,t,L}(1-\lambda_{\tilde{r}(r')}\Lambda^s_{r',y,t,L}) & \text{if } r \text{ is a destination region} \end{cases} \quad (2)$$

where $\lambda_{\tilde{r}}$ is the movement rate from transect $\tilde{r}\,r$, $\Lambda^s_{r,y,r,L}$ is the fraction of the animals of sex *s* in length-class *L* in region *r* during time-step *t* of year *y* which are "whites"[7]:

$$\Lambda^s_{r,y,t,L} = \frac{K_{r,y,L}}{\sqrt{2\pi}\sigma^{\Lambda}_{r,y}} e^{-\frac{(\ell_L - P^{\Lambda}_{r,y})^2}{2(\sigma^{\Lambda}_{r,y})^2}} \quad (3)$$

$K_{r,y,L}$ is a scaling factor, $P^{\Lambda}_{r,y}$ / $\sigma^{\Lambda}_{r,y}$ are the mean and standard deviation of the length which defines the probability of an animal being a "white", ℓ_L is the midpoint of length-class *L*, and $v_{r',r}$ is the fraction of animals which move from region *r'* to region *r*.

The number of animals after mortality during time-step *t* of year *y* accounts for landings and discards, and that fishing and natural mortality differ between "whites" and "reds", and is given by:

[7] This function is zero for time-steps 7-24.

$$N^s_{r,y,t,L} = \tilde{\tilde{N}}^s_{r,y,t,L}[\Lambda^s_{r,y,t,L} e^{-Z^s_{1,r,y,t,L}} + (1-\Lambda^s_{r,y,t,L}) e^{-Z^s_{2,r,y,t,L}}] \quad (4)$$

where $Z^s_{\tau,r,y,t,L}$ is the total mortality on animals of type τ (1="whites", 2="reds") in length-class *L* and region *r*, during time-step *t* of year *y*:

$$Z^s_{\tau,r,y,t,L} = F^s_{\tau,r,y,t,L} + M_{\tau,y,t} + D^s_{\tau,r,y,r,L} \quad (5)$$

where $F^s_{\tau,r,y,t,L}$ is the fishing mortality associated with the landed catch of animals of type τ in length-class *L* and region *r* during time-step *t* of year *y*, $D^s_{\tau,r,y,t,L}$ is the fishing mortality associated with the discarded catch of animals of type τ in length-class *L* and region *r* during time-step *t* of year *y*, and $M_{s,y,t}$ is the instantaneous rate of natural mortality on animals of type τ during time-step *t* of year *y*.

B. Catches and fishing mortality

The landed catch (in weight) from region *r* during time-step *t* of year *y*, $\hat{C}_{r,t,y}$, is:

$$\hat{C}_{r,y,t} = \sum_s \sum_L W^s_L \tilde{\tilde{N}}^s_{r,y,t,L} \left\{ \frac{\Lambda^s_{r,y,t,L} F^s_{1,r,y,t,L}}{Z^s_{1,r,y,t,L}} (1 - e^{-Z^s_{1,r,y,t,L}}) + \frac{(1-\Lambda^s_{r,y,t,L}) F^s_{2,r,y,t,L}}{Z^s_{2,r,y,t,L}} (1 - e^{-Z^s_{2,r,y,t,L}}) \right\} \quad (6)$$

where W^s_L is the weight of an animal of sex *s* in length-class *L*.

The discarded catch (in weight) from region *r* during time-step *t* of year *y*, $\hat{D}_{r,t,y}$, is:

$$\hat{D}_{r,y,t} = \sum_s \sum_L W^s_L \tilde{\tilde{N}}^s_{r,y,t,L} \left\{ \frac{\Lambda^s_{r,y,t,L} D^s_{1,r,y,t,L}}{Z^s_{1,r,y,t,L}} (1 - e^{-Z^s_{1,r,y,t,L}}) + \frac{(1-\Lambda^s_{r,y,t,L}) D^s_{2,r,y,t,L}}{Z^s_{2,r,y,t,L}} (1 - e^{-Z^s_{2,r,y,tL}}) \right\} \quad (7)$$

The fishing mortality by type and landed / discarded is given by:

$$\begin{aligned} F^s_{1,r,y,t,L} &= V^{W,s}_{r,y,t,L} q^A_L q^W_{r,t} \theta^W_{r,y,t} E_{r,y,t} \\ F^s_{2,r,y,t,L} &= V^{R,s}_{r,y,t,L} q^A_L q^R_r \theta^R_{r,y,t} q^w_{r,y,t} E_{r,y,t} \\ D^s_{1,r,y,t,L} &= \delta(1 - V^{W,s}_{r,y,t,L}) q^A_L q^W_{r,t} \theta^W_{r,y,t} E_{r,y,t} \eta_{y,L} \\ D^s_{2,r,y,t,L} &= \delta(1 - V^{R,s}_{r,y,t,L}) q^A_L q^R_r \theta^R_{r,y,t} q^w_{r,y,t} E_{r,y,t} \eta_{y,L} \end{aligned} \quad (8)$$

where $V^{\tau,s}_{r,y,t,L}$ is the availability of animals of type τ, sex *s* and length-class *L* for capture during time-step *t* of year *y*, q^A_L is the length-specific selectivity for animals in length-class *L*:

$$q^A_L = 1.151 - 0.0072 \ell_L \quad (9)$$

$q^W_{r,t}$ is the catchability coefficient for "whites" in region *r* during time-step *t*, q^R_r is the catchability coefficient for "reds" in region *r* (assumed to be the same for all time-

steps) $\theta^{\tau}_{r,y,t}$ is the relative efficiency for fishing for animals of type τ in region *r* during time-step *t* of year *y*, $q^{w}_{r,y,t}$ is the impact of temperature on the catchability of "reds" in region *r* during time-step *t* of year *y*:

$$q^{w}_{r,y,t} = 1 + \gamma_1 T^2_{r,y,t} + \gamma_2 T_{r,y,t} + \gamma_3 \tag{10}$$

$T_{r,y,t}$ is the temperature in region *r* during time-step *t* of year *y*, $\gamma_1, \gamma_2, \gamma_3$ are the parameters of the temperature-catchability relationship, $E_{r,y,t}$ is the effort (in potlifts) in region *r* during time-step *t* of year *y*, δ is the mortality rate for discards, and $\eta_{y,L}$ is the impact of escape gaps during year *y* on animals in length-class *L*.

C. Initial conditions

The size-structure by sex in each region at the start of the first year (1975) is calculated by projecting an arbitrary size-structure for 1970 forward under a constant fishing mortality, F^{I}_{r}, and treating the recruitments for 1970-74 as estimable parameters.

D. Outputs

The key output statistic is the egg production by region. Egg production is defined as:

$$Egg_{r,y} = \sum_{L} N^{\text{fem}}_{r,y,t,L}\, \omega_{r,y,L} \tag{11}$$

where $\omega_{r,y,L}$ is the expected number of eggs produced by a female in length-class *L* and region *r* during year *y*:

$$\omega_{r,y,L} = \left(\frac{1}{1+e^{-\ell n 19(\ell_L - L_{50,y})/(L_{95,y} - L_{50,y})}} + \frac{1}{1+e^{-\ell n 19(\ell_L - D_{50,y})/(D_{95,y} - D_{50,y})}} \right)^{8} \tag{12}$$

where $L_{50,y}, L_{95,y}$ are the parameters of egg-length relationship for single breeding, and $D_{50,y}, D_{95,y}$ are the parameters of egg-length relationship for double breeding,

E. Parameterization and objective function

Most of the parameters of the population dynamics model are pre-specified rather than being estimated by fitting the model to the available data. Table 1 lists all of the parameters of model, indicating which are pre-specified and which are estimated. Table 2 lists all of the data on which parameter estimation is based.

The model considers 45 length-classes from 40mm 135+mm with boundaries at 40, 42, 44, 46, 48, 50, 52, 54, 56, 58, 60, 62, 64, 66, 68, 70, 72, 23, 74, 75, 76, 77, 78, 79, 80, 82, 84, 86, 88, 90, 92, 94, 96, 98, 100, 102, 104, 105, 107, 109, 111, 113, 114, 115, and 135+mm. Growth occurs during time-steps 3 and 9 while movement occurs

[8] This equation should be checked in the code.

during time-step 4. Whites are only assumed to occur during time-steps 1-6. The catchability coefficients for whites by time-step are parameterized as follows:

$$q^{W}_{r,t} = \begin{cases} q^{1}_{r} & \text{if } t = 1,2,6 \\ q^{2}_{r} & \text{otherwise} \end{cases} \tag{13}$$

where q^{1}_{r} and q^{2}_{r} are estimated parameters

Natural mortality is assumed to be time-invariant over the period of the historical assessment and equal to M^{τ} for "whites" and "reds".

The availability to capture changes over time as a function of management rules:

$$V^{s}_{\substack{r,y,t,L \\ y<1993}} = \begin{cases} 0 & \ell_L < 76\text{mm or } \ell_L > L_{\max} \\ 1 & s = \text{male};\ \ell_L \geq 76\text{mm and } \ell_L \leq L_{\max} \\ O_{r,t} & s = \text{female};\ \ell_L \geq 76\text{mm and } \ell_L \leq L_{\max} \end{cases} \tag{13a}$$

$$V^{s}_{\substack{r,y,t,L \\ t\leq 6;\, y\geq 1993}} = \begin{cases} 0 & \ell_L < 77\text{mm or } \ell_L > L_{\max} \\ 1 & s = \text{male};\ \ell_L \geq 77\text{mm and } \ell_L \leq L_{\max} \\ O_{r,t} & s = \text{female};\ \ell_L \geq 77\text{mm and } \ell_L \leq L_{\max} \end{cases} \tag{13b}$$

$$V^{s}_{\substack{r,y,t,L \\ y>1993}} = \begin{cases} 0 & \ell_L < 76\text{mm or } \ell_L > L_{\max} \\ 1 & s = \text{male};\ \ell_L \geq 76\text{mm and } \ell_L \leq L_{\max} \\ S_{r,t} & s = \text{female};\ \ell_L \geq 76\text{mm and } \ell_L \leq L_{\max} \end{cases} \tag{13c}$$

where $O_{r,t}$ is the proportion of ovigerous females in region *r* during time-step *t*, $S_{r,t}$ is the proportion of setose females in region *r* during time-step *t*[9], and $L_{\max}$ is the maximum length.

The objective function contains five terms. Four of these relate to fitting the catch, commercial length-frequency, IBSS length-frequency and IBSS index data, and the fifth is a penalty on the recruitment deviations by transect.

The contribution of the catch data to the objective function is based on the assumption the square root of the observed catch is normally distributed about the model prediction, i.e.:

$$L_1 = \kappa_1 \sum_r \sum_y \sum_t \left\{ \ell \text{n} \sigma^{C}_{r} + \tfrac{1}{2(\sigma^{C}_{r})^2} (\sqrt{\hat{C}_{r,y,t}} - \sqrt{C^{\text{obs}}_{r,y,t}})^2 \right\} \tag{14}$$

where $C^{\text{obs}}_{r,y,t}$ is the observed catch (in weight) in region *r* during time-step *t* of year *y*, σ^{C}_{r} is the (estimated) extent of measurement error for region *r*, and κ_i is the weight assigned to the i^{th} data source.

[9] Should O and S not also depend on length?

The contribution of commercial length-frequency data to the objective function is based on the assumption that the length-frequency data are a multinomial sample of the catches-by-length, i.e.:

$$L_2 = -\kappa_2 \sum_s \sum_r \sum_y \sum_t C^L_{s,r,y,t,L} \ell \mathrm{n} \rho^L_{s,r,y,t,L} \tag{15}$$

where $C^L_{s,r,y,t,L}$ is the observed number of animals of sex *s* in region *r* in length-class *L* caught during time-step *t* of year *y*, and $\rho^L_{s,r,y,t,L}$ is the model-estimate corresponding to $C^L_{s,r,y,t,L}$, i.e.:

$$\rho^L_{s,r,y,t,L} = \frac{\eta_{y,L} q^A_L N^s_{r,y,t,L}}{\sum_{L'} \eta_{y,L'} q^A_{L'} N^s_{r,y,t,L'}} \tag{16}$$ [10]

The contribution of the IBSS length-frequency data to the objective function is based on the assumption that the length-frequency data are a multinomial sample of the survey-selected abundance, i.e.:

$$L_3 = -\kappa_3 \sum_s \sum_r \sum_y \sum_t C^{IBSS}_{s,r,y,t,L} \ell \mathrm{n} \rho^{IBSS}_{s,r,y,t,L} \tag{17}$$

where $C^{IBSS}_{s,r,y,t,L}$ is the observed number of animals of sex *s* in region *r* in length-class *L* caught during the IBSS survey in time-step *t* of year *y*, and $\rho^{IBSS}_{s,r,y,t,L}$ is the model-estimate corresponding to $C^{IBSS}_{s,r,y,t,L}$, i.e.:

$$\rho^{IBSS}_{s,r,y,t,L} = \frac{\tilde{S}_L \, q^A_L \, N^s_{r,y,t,L}}{\sum_{L'} \tilde{S}_{L'} \, q^A_{L'} \, N^s_{r,y,t,L'}} \tag{18}$$

where $\tilde{S}_L$ is the selectivity pattern for the IBSS surveys, i.e.:

$$\tilde{S}_L = (1 + e^{-\ell n 19 (\ell_L - \tilde{L}_{50}) / (\tilde{L}_{95} - \tilde{L}_{50})})^{-1} \tag{19}$$

$\tilde{L}_{50}, \tilde{L}_{95}$ are the parameters which determine the selectivity pattern for the IBSS surveys.

The contribution of the IBSS index to the objective function is based on the assumption that survey catch-rates (in numbers?) are log-normally distributed about the model prediction, i.e.:

$$L_4 = \kappa_4 \sum_r \sum_t \sum_y \left\{ \ell n \sigma^{IBSS}_{r,t} + \frac{1}{2(\sigma^{IBSS}_{r,t})^2} (\ell n IBSS_{r,y,t} - \ell n (q^{IBSS}_{r,t} \tilde{N}^{IBSS}_{r,y,t}))^2 \right\} \tag{20}$$

[10] This equation needs to be checked in the code.

where $IBSS_{r,y,t}$ is the catch-rate index from the IBSS survey for region *r* during time-step *t* of year *y*, $\tilde{N}^{IBSS}_{r,y,t}$ is the model-estimate of the IBSS survey index:

$$\tilde{N}^{IBSS}_{r,y,t} = \sum_{s}\sum_{L} \tilde{S}_L \, q^A_L \, N^s_{r,y,t,L} \tag{21}$$

$q^{IBSS}_{r,t}$ is the catchability coefficient for the IBSS survey, and $\sigma^{IBSS}_{r,t}$ is the extent of sampling error for the IBSS survey.

The penalty imposed on the recruitment deviations is based on the assumption that the puerulus counts provide indices of recruitment after log-transformation, i.e.:

$$L_5 = \kappa_5 \sum_{\tilde{r}}\sum_{y} \left\{ \ell \mathrm{n} \sigma^P_{\tilde{r},y} + \tfrac{1}{2(\sigma^P_{\tilde{r},y})^2} (\varepsilon_{\tilde{r},y} - \alpha_{\tilde{r}} \varepsilon^P_{\tilde{r},y})^2 \right\} \tag{22}$$

where $\alpha_{\tilde{r}}$ is the constant of proportionality between the puerulus indices and the recruitment deviations for transect $\tilde{r}$, $\sigma^P_{\tilde{r},y}$ is the error between the puerulus counts and the recruitment deviations:

$$\sigma^P_{\tilde{r},y} = \sqrt{(CV^P_{\tilde{r},y})^2 + \varphi^2} \tag{23}$$

$CV^P_{\tilde{r},y}$ is the sampling coefficient of variation for the puerulus count for transect $\tilde{r}$ and year *y*, φ is the uncertainty of the relationship between puerulus counts of recruitment deviations, $\varepsilon^P_{\tilde{r},y}$ is the normalized puerulus count for transect $\tilde{r}$ and year *y*:

$$\varepsilon^P_{\tilde{r},y} = \ell n P_{\tilde{r},y} - \frac{\sum_{y=1975}^{2008} \ell n P_{\tilde{r},y}}{2008 - 1975 + 1} \tag{24}$$

where $P_{\tilde{r},y}$ is the puerulus count for transect $\tilde{r}$ during year *y*.

E. Projections

The aim of the projections is calculate the egg production in future years under specified levels of effort as well as the expected values for natural mortality, and egg production as a function of length. The projections allow for uncertainty in natural mortality, egg production as a function of length, and recruitment. This is achieved by parameterizing these three quantities for year $y > 2008$ as follows:

$$
\begin{aligned}
M_{\tau,y,t} &= M_{\tau} e^{\zeta_y^1 - (\sigma^M)/2} & \zeta_y^1 &\sim N(0;(\sigma^M)^2) \\
L_{50,y} &= L_{50,y} + \zeta_y^2 & \zeta_y^2 &\sim N(0;(\sigma_{L_{50,y}})^2) \\
L_{95,y} &= L_{95,y} + \zeta_y^3 & \zeta_y^3 &\sim N(0;(\sigma_{D_{95,y}})^2) \\
D_{50,y} &= D_{50,y} + \zeta_y^4 & \zeta_y^4 &\sim N(0;(\sigma_{D_{50,y}})^2) \\
D_{95,y} &= D_{95,y} + \zeta_y^5 & \zeta_y^5 &\sim N(0;(\sigma_{D_{95,y}})^2) \\
\varepsilon_{\tilde{r},y} &= \alpha_{\tilde{r}} \varepsilon_{\tilde{r},t}^P + \zeta_y^6 & \zeta_y^6 &\sim N(0;(\sigma^R)^2)
\end{aligned}
\qquad (25)
$$

where σ^M is the extent of uncertainty in natural mortality, $\sigma_{L_{50}}, \sigma_{L_{95}}$, $\sigma_{D_{50}}$ and $\sigma_{D_{95}}$ reflect the uncertainty in the projected egg production-length relationship, and σ^R is the extent of variation in recruitment (about the assumed puerlus count for each future year *y*). Terms are added the objective function to implement the random components of Equation 25.

Table 1. List of the parameters of the population dynamics model

Parameter	Treatment
Population dynamics model	
Initial fishing mortality, F_r^I	Estimated (one per region)
Growth matrix, $\mathbf{G}_r^s$	Pre-specified
Normal distribution for whites, $K_{r,y,L}, P_{r,y}^{\Lambda}, \sigma_{r,y}^{\Lambda}$	Pre-specified
Egg production – length parameters, $L_{50,y}, L_{95,y}, D_{50,y}, D_{95,y}$,	Pre-specified
Natural mortality, M^{τ}	Pre-specified
Proportion of ovigerous females, $O_{r,t}$	Pre-specified
Average recruitment, R_r	Estimated (one per region)
Proportion of setose females, $S_{r,t}$	Pre-specified
Availability to capture, $V_{r,y,t,L}^{\tau,s}$	Pre-specified
Weight-at-length W_L^s	Pre-specified
Catchability for reds, q_r^R	Estimated (one per region)
Catchability for whites, q_r^1, q_r^2	Estimated (two per region)
Discard mortality, δ	Pre-specified
Recruitment deviations, $\varepsilon_{\tilde{r},y}$	Estimated (one per year and transect)
Temperature-catchability parameters, $\gamma_1, \gamma_2, \gamma_3$	Estimated (three parameters)
Movement rate, λ_r	Pre-specified
Impact of escape gaps, $\eta_{y,L}$	Pre-specified
Proportion recruiting by length, ϕ_L	Pre-specified
Efficiency increase, $\theta_{r,y,t}^{\tau}$	Pre-specified
Observation model	
Proportionaility for the puerulus data, $\alpha_{\tilde{r}}$	Estimated
IBSS selectivity, $\tilde{L}_{50}, \tilde{L}_{95}$	Estimated (two parameters)
Catchability coefficient for the IBSS survey, $q_{r,t}^{IBSS}$	Estimated
Puerulus count uncertainty, φ	Pre-specified[11]
Catch measurement variation, σ_r^C	Estimated
Extent of sampling error for the IBSS survey, $\sigma_{r,t}^{IBSS}$	Estimated

[11] Not implemented in the code yet

Table 2. The data used when projecting the population dynamics model.

Data type
Fishing effort, $E_{r,y,t}$
Temperature, $T_{r,y,t}$
Catch-in-weight, $C^{\text{obs}}_{r,y,t}$
Commercial length-frequency data, $C^{L}_{s,r,y,t,L}$
IBSS length-frequency data, $C^{IBSS}_{s,r,y,t,L}$
IBSS catch-rare, $IBSS_{r,y,t}$
Normalized puerulus count, $\varepsilon^{P}_{\tilde{r},y}$
CV of the puerulus count, $CV^{P}_{\tilde{r},y}$

Appendix 8 – List of invitees / attendees

Invitations

Invitations were sent to the following stakeholders:

Fishing Industry

- The Western Rock Lobster Council (i.e. it Directors) and through it all professional rock lobster fishers associations and processors on the west coast.
- Individual rock lobster fishers, pot and boat owners and dealers who had expressed interest in attending.

Recreational fishers

- Recfishwest

Conservation stakeholders

- WWF – Australia
- Conservation Council of WA

Department of Fisheries research and management staff

Workshop Attendees

<u>Department of Fisheries</u>
Rick Fletcher
Peter Stephenson
Nick Caputi
Simon de Lestang
Rhys Brown
Jason How
Adrian Thomson
Dan Gaughan
Brent Wise
Lynda Bellchambers
Rod Lenanton
Eva Lai
Anthony Hart
Matt Pember
Brett Molony
Arani Chandrapavan
Eric Barker
Mark Rossbach
Mervi Kangas
Jo Kennedy
Kevin Donohue
Phil Unsworth

<u>External experts</u>
Norm Hall

Klaas Hartmann
Andre Punt
Cathy Dichmont
Kim Ley Cooper

Stakeholders
Dexter Davis (Executive Officer WRLC)
Ron Jennifer Maloney (fishers)
Garry Coleman (Fisher)
Anthony Santaromita (fisher)
Mark ?
John Cole (Chairmen of WRLC and fisher)
John Newby (Chairman of Western Australian Fishing industry Council)
Terry Lissiman (fisher)
Gil Waller (pot and boat broker and owner)
Clinton Moss (fisher)
Fedele Camarda (fisher)
Peter Prideaux (fisher)

Appendix 9 – Questions for Review Panel to consider

SPECIFIC QUESTIONS FOR REVIEWERS

Units of Management and Decision-rule framework

What are the most appropriate geographic boundaries/units of management that should be use to monitor and manage egg production levels? If the current three management zones, are not considered sufficiently appropriate, what would be the more robust set of units (noting that licenses are currently linked to individual zones)?

Are the current threshold levels of egg production used in each zone, including the degree of certainty required (currently > 75%) and the time scale (currently 5 years in advance) still appropriate given the shift to quotas, the information now available on source sink, recruitment levels and migration and potentially a change in management units (see previous point)?

What would be the option(s) for efficiently determining target level for each zone (or the entire fishery) to apply the principles of an Annual MEY (recognising that the recruitment costs, prices will to vary annually) e.g. would having a target level of egg production per zone that is consistent with an average MEY level of harvest be suitable?

Model Inputs

Are the changes in SAM (size at maturity) now appropriately included in the model?

Are the changes in fishing efficiency now appropriately included in the model?

Are the uncertainties in inputs included appropriately in the model?

Is the method for estimating depletion within the model by fitting to seasonal trends in catch rates now sufficiently robust?

Is the method for inputting the relationship between puerulus settlement and recruitment (based on a relationship estimated outside the model) into the assessment model acceptable?

Has the lobster size frequency data now been incorporated appropriately into the assessment?

Model Structure

What is the most robust and efficient manner to include the IBSS indices (including their measurement uncertainties and the impacts of environmental conditions) within the objective function? Should the fishery-dependent BSI also be included in the objective function?

What is the most efficient structure for the model in terms of spatial units, length bins and time steps to deal with the shift to quota based management, and targeting MEY levels?

Does the model structure easily link to the bioeconomic modelling that is proposed?

Quota Assessment Method

Does the model provide robust projections for egg production into the future to enable proposed management settings (quota and other measures) to be examined with sufficient confidence?

What is considered to be the benefits and/or costs associated with setting quotas to meet the management objectives if this was to be done annually or if this was to be set every three years?

In relation to the examination of the most appropriate units of management, what are the implications for the quota being set as one integrated figure and allocated to units against being set ‘separately’ for each management unit/zone?

Harvest Strategy Decision Rules

What advice can be provided for moving this framework from one that was based on input controls and largely MSY based settings, to a quota targeting MEY based principles?

Have the uncertainties associated with the cause of the low puerulus been sufficiently covered by the model and the associated harvest strategy/ decision rules framework?

Appendix 10 – Comparison of ITE and new ITQ models for Zone C

Changes made to the current ITE model by Andre Punt during the workshop.

Peter Stephenson & Simon de Lestang

During the workshop Andre Punt started the migration of the latest version of the ITE model towards a model that would include features appropriate for an ITQ fishery. The resultant model, which will be referred to as the ITQ version, was modified to include changes to the code that would increase the efficiency of the calculations, and thus the processing speed, and to change some features that the assessment team felt were inappropriate. Significant changes between the ITE and ITQ model were:

1. The processing speed was increased significantly by synthesising the computer code and eliminating areas when calculations were repeated, e.g. in the calculation of the catches and the discards.
2. The calculation efficiency was improved by attempting to eliminate calculations when the numbers were zero, especially in allocating animals to length bins.
3. The weighting of catches in the objective function to improve the fit of large catches was changed by changing the log transformation to a square-root transformation.
4. The length composition likelihood was adjusted based on its level of variance (T) as determined by the value of x when the following equation is equal to 1: $\mathrm{var}\left((obs-est)/\sqrt{est*(1-est)/x*n}\right)$, where obs is the observed length composition, est is the estimated length composition and n is the observed sample size.
5. The initial state of the model was changed from being some proportion of the state estimated by the model in 1980 to one in which, prior to 1975, the mean recruitment and recruitment deviations in each region were estimated.
6. A number of parameters and variables previously estimated outside of the model are now fully incorporated and estimated within the model.
7. The introduction of variability in natural mortality and egg production in the projections was re-written to make it more conventional and efficient.
8. Catch, effort and length composition data from the IBSS was incorporated into the assessment model.

To achieve these modifications in the short time available, only the Zone C version of the ITE model was migrated to an ITQ model. This revision was a significant task and it was expected that some 'bugs' would appear in the code.

Once the ITQ model was running properly, with discovered bugs rectified, an estimate of egg production, which is the most important output in terms of sustainability assessment and management advice, was compared to that produced by the previous ITE model. This comparison was undertaken as quickly as possible as it directly relates to the robustness of recent management advice and it was important to ascertain whether this advice would have been the same based on either version of the model.

The comparison indicated that the median estimates of egg production produced by the two models were similar and that recent management advice would not have been different if based on the ITQ model (figures below). This C zone comparison therefore indicates the current stock assessment of sustainability in Zone C was robust. However, because Zone C will be the zone most affected by the very low puerulus settlements, it also implies that the current stock assessments of sustainability for the other two zones of the fishery (Zones A and B) were also robust.

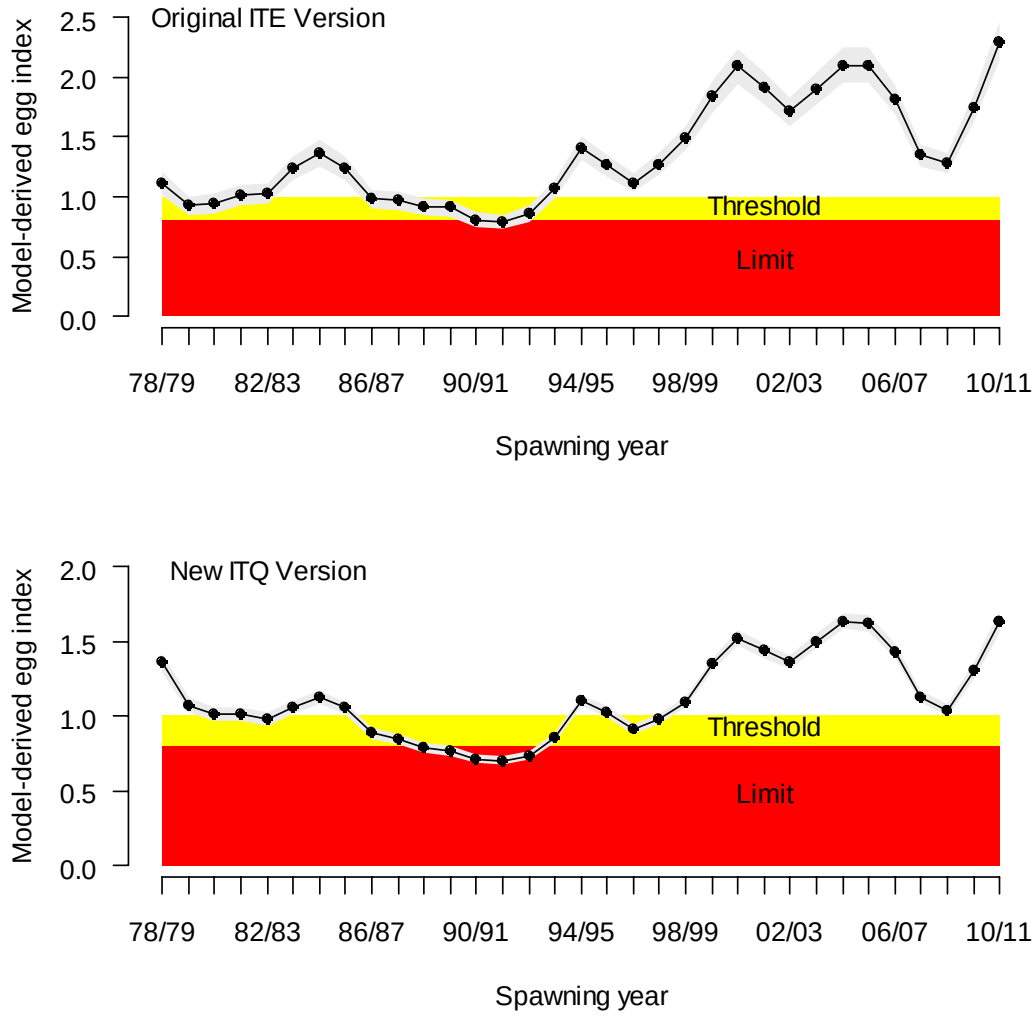

Figure 1. Estimates of egg production in Zone C of the Western Rock Lobster (WRL) fishery based on the ITE and ITQ versions of the WRL Stock Assessment model. The black lines represent the median estimate of egg production, the grey polygon the 50% confidence region, the yellow rectangle the threshold region and the red rectangle the limit region.

Appendix 11 – Action Plan to Address Review Panel's Recommendations

The Panel **recommends** that, in the short term (e.g. by the end of 2010) and in order of priority, the following actions be undertaken:

Review Panel's Short Term Recommended Actions	Current Status and Proposed Actions	Completion Date
1 The assessment team should critically examine the new data inputs and ADMB code for the new ITQ model to verify that the intended revised model structure is correctly implemented. This is likely to be facilitated by revising the mathematical description that summarises the equations (Appendix G) that are implemented in the revised ADMB code. Errors that are detected should be corrected.	The new data inputs for use in the new ITQ model have been examined and further modified. The ADMB code for the new ITQ model has been examined (via both the mathematical descriptions in Appendix G and the ADMD tpl file) to identify errors, which have been corrected, and to determine this codes appropriateness to this fishery.	**Completed** **Completed**
2 The assessment team should confirm that, when using different initial values of parameters, the new ITQ model converges to the same parameter estimates, e.g. through a jitter analysis. Details of the analysis and the results should be documented. Problems in obtaining convergence should be addressed.	The new (updated version) of the ITQ model has been subjected to and passed a 'jitter analysis'. This will be re-applied to the model as it is further developed, i.e. after the implementation of all zones and a reduction in time-steps.	**Completed**
3 Computer software should be developed to automate the production of detailed and complete model and diagnostic outputs, e.g. tables of indicator variables and reference points, plots of predicted versus observed values, results of residual analysis, bubble plots of Pearson residuals for length composition data, etc. Such software will assist in reporting the details of the assessment and the results and will facilitate evaluation of the model's integrity.	A script has been developed in R that automates the manipulation and plotting of a range of model and diagnostic outputs (diagnostics outputs are based on those produced by Prof Punt for the Alaskan King Crab Fishery in May 2009).	**Completed**

4 The assessment team should identify key indicator variables and reference points that should be considered when comparing the results of sensitivity tests and which will be required by the decision rules and by managers and fishers seeking to assess the management implications of model results. These indicator variables will include results of model projections. If necessary, the ADMB code should be modified to calculate and output the required statistics.	The R script described above summarizes a range of key indicator variables and reference points (e.g. estimates of egg production, harvest rates, vulnerable biomass and catch rates) that are used both to compare model runs and for assessing management implications.	**Completed**
5 The revised model should be run, with the results being accepted as the current base case. Details of the analysis, the parameter estimates, asymptotic standard errors, parameter correlation matrix, and detailed diagnostic outputs should be documented and examined. Errors detected in the results should be resolved by correcting the code and the model description. The assumptions of the model may need to be modified and a new base case generated if the diagnostics identify a major structural uncertainty with the model. Sensitivity analyses identified below may assist in determining how the model may need to be restructured.	The new ITQ model is currently being expanded to include all sections of the fishery, migration between these sections, as well as a modified temporal scale. Upon completion and the model passing tests of sensitivity, consistency and jitter analysis, the outputs will be considered as the base case. This model version will then be fully described, including all diagnostics, in the current Stock Assessment document on the Department's website.	**In progress** – projected completion date November 2010.
6 The assessment team should develop an explicit list of key uncertainties in model assumptions that reflect uncertainties in model structure and that should be considered as alternative cases. A critical assessment of the diagnostic outputs for the base case model is likely to assist in identifying aspects of the model requiring exploration though sensitivity tests.	As the model is currently being expanded (see above) it is not yet possible to determine key areas of uncertainty. However, the assessment team foresee that key areas may be initial fishing mortality and recruitment, future recruitment, error in *M* and changes in growth rates.	After completion of 5 above. Anticipated November 2010, or end of 2010.

7 The model should be re-run to explore the sensitivity of results to each of the alternative model cases. Results of the alternative models should be compared with the results from the base case model. The contributions of components to the likelihood should be used to develop likelihood profiles for selected key input parameters, such as natural mortality.	This will be conducted after the completion of the base case of the model and the development of an explicit list of areas of uncertainty.	After completion of 6 above.
8 Results of the above analyses should be critically assessed to determine whether the results from the base case model are appropriate for determining the status of the fishery and advising on the appropriateness of alternative management strategies. The results of the diagnostic plots will be crucial for this assessment, and may identify deficiencies in model structure that must be addressed before model results can be considered reliable (see Point 5, above). The results from the sensitivity runs should be used to provide information on the uncertainty of the results associated with model structure and data inputs if the base-case model is considered acceptable. The results of this assessment should be documented.	Once completed the base-case version of the model will be fully described, including all diagnostics and sensitivity analysis, in the current Stock Assessment document on the department website.	After completion of 7 above.
9 The current value of a target reference point, based on current and projected costs and prices and using an egg production or harvest rate proxy to an "equilibrium" MEY level, should be determined for use in the decision rules to be applied to the fishery.	The Decision Rule framework is being revised as a result of moving to an ITQ management. Funding has been secured to examine the MEY assessment under ITQ.	Completion anticipated by the end of 2011. Research project on MEY assessment is due to be completed in June 2013.

10 The results of the base case model, and the alternative models, should be considered in the context of the decision rules for the fishery to determine whether the current management regime adopted for the fishery is adequate to maintain the egg production of the stock at a level consistent with the requirements of the decision rules, and likely to be consistent with regulations required to attain the target reference point.	When the base-case and alternatives of the model has been completed and examined their impact on the current framework of decision rules will be discussed with industry and management.	After completion of 8 above.
11 A more detailed and clearer description of the model should be published.	Once completed the base-case version of the model will be fully described, including all diagnostics and sensitivity analysis, in the current Stock Assessment document on the Department's website.	After completion of 7 above.
12 To reduce model dimensionality, the model should be further revised to merge the regions that, on the basis of correlations among regions of, for example, catch-rates and puerulus settlement data, appear to be candidates for combination. Model results before and after merging regions should be compared to determine whether the simplified model improves the robustness of the results and to confirm that the model revision has had no unintended consequences.	The new ITQ model is currently being expanded to include all sections of the fishery, migration between these sections, as well as a modified temporal scale. As part of this process a number of spatial cells in the ITQ version of the model are being amalgamated to reduce the dimensionality.	In progress – projected completion date November 2010.
13 A version control system, such as TortoiseSVN, should be implemented.	A number of version control system are currently being examined and one will be chosen and implemented shortly.	In progress – projected completion date November 2010.

Action Plan continued

The Panel further **recommends** that, in the longer term and in order of priority, the following actions be undertaken:

Review Panel's Longer Term Recommended Actions	Current Status and Proposed Actions	Completion Date
1 A Research Assessment Group (RAG) should be established to ensure ongoing review of stock assessments and collaboration with rock lobster scientists from other states, many of whom are using or developing similar models for lobster fisheries.	A RAG will be established.	2011 - 2012
2 The data sources used in the model should be examined to determine whether all data sources that are available are currently being utilised and, if so, whether such use is internal or external to the model. If external, consideration should be given to undertaking the analyses within the model and thereby taking the uncertainty associated with such analyses into account. As many parameters as possible should be estimated within the model. In particular, estimates of annual increases in efficiency since 1990/91 should be determined within the model.	All available data for the western rock lobster fishery is currently or planned to be inputted into the model. Some data sources such as growth equations, which require some level of subjective analysis (e.g. when applying length cohort analysis) may continue to be developed externally to the model with associated levels of error inputted to the model.	2011 - 2012
3 The relationship between catchability and length should be based on fitting a function to the estimates of fishing mortality by length class. Alternative functional forms should be considered as sensitivity cases.	Different functions and their appropriateness will be investigated.	2011 - 2012
4 Estimates of effective sample size should be obtained and included in the calculation of the likelihood of the length composition samples.	Estimates of effective sample size have been obtained and are included in the calculation of the likelihood of the length composition samples.	Completed

5 Use of robustified versions of likelihood functions should be considered.	Robustified versions of likelihood functions are being considered.	2011 - 2012
6 A detailed description of the methods used to convert raw data to the data that are input to the model should be produced.	A detailed description of the methods used to convert raw data to the data that are input to the model are being produced and will be published in the Stock Assessment document on the Departments website.	In progress
7 The length bin structure is specified as an input to the model. The model should be modified to allow for a more flexible length bin structure to further reduce model's dimensionality. Length bins could be defined at run-time and with the code automatically reconfiguring the data to fit the specified length bin structure. Sensitivity runs should be undertaken to determine whether a simplified length composition structure with fewer bins would produce results consistent with those obtained using the current number of length bins.	The model has been modified to alter the length bin structure.	Completed
8 The impact on management advice of reducing the number of spatial cells considered within the model through introduction of a "fleet" concept employing different selectivity patterns for different fleets should be considered, and an assessment made of whether such a simplified model should be adopted in place of some aspects of the more complex model.	The use of a fleet concept in the model has been considered and may be appropriate for the recreational component.	In progress
9 The existing models should be combined to form a single model that includes all regions within all zones, i.e. A, B, and C.	The new ITQ model is currently being expanded to include all sections of the fishery, migration between these sections as well as a modified temporal scale.	In progress
10 The model (for the entire fishery) should be extended to include migration among regions and zones using estimates of parameters relating to migration derived (internally) from tagging data.	The new ITQ model is currently being expanded to include all sections of the fishery, migration between these sections, as well as a modified temporal scale. The inclusion of the tagging data to aid in the model estimation of movement patterns is planned.	In progress

11 An MSE should be developed, and the effectiveness of alternative decision rules, and the robustness of these decision rules under the alternative hypotheses relating to the cause of the recent decline in puerulus settlement, should be explored. For example, an MSE could be used to assess whether it is more effective to use a four or five year projection period for the decision rule requiring that, for each year of this period, the probability of predicted annual egg production being greater than the threshold exceeds 70%.	An MSE is planned to test the effectiveness of alternative decision rules, and the robustness of these decision rules.	After formal completion and peer review of the model.

Appendix 12 – Progress to Meet MSC Conditions

Progress to meet MSC conditions set at the November 2009 surveillance

Note: This progress report should be read in conjunction with the section headed "**E. Response to MSC concerns**" of the Review Panel's report, which at Appendix 7.

Stock Assessment and Modelling

MSC Condition	Status	Completion date
Condition 1.1.1.5 (2009): The client shall provide to the CB a report showing how current major uncertainties in BSS and IBSS indices, including changes in maturity and environmentally induced inter-annual changes in catchability, have been addressed. The report will include revised time series for estimates of breeding stock, including confidence bounds and the way that they reflect the uncertainties in the analyses. The report shall be reviewed as part of the international review of the stock assessment (see indicator 1.1.5.1) and the reviewed and agreed time series will then be used in the quantitative stock assessment. **Timeline:** Report to be provided to CB by March 2010 for subsequent review by international peer reviewer.	**Completed**. The required report (an update of the *Stock Assessment of the West Coast Rock Lobster Fishery*) was provided to the CB and the Review Panel on 7 May 2010. Two other 'reports' were also requested by the Review Panel – comparing observed and model generated CPUEs and length class data (as bubble plots).The report(s) was reviewed at the Review Workshop - 20 to 24 May 10.	**Completed**
Condition 1.1.5.1 (2009): *(This condition also applies to indicators 1.1.2.2, 1.1.5.2 & 1.1.5.5)* Undertake an international peer review of the current (2009) stock assessment and work with the peer reviewer(s) to develop a robust assessment of the stock. Issues to be addressed include:	An international peer review of the current (2009) stock assessment has been undertaken and the DoF stock assessment team has worked with the peer reviewers to develop a more robust model and assessment of the	**Completed**

• Estimating depletion within the model by fitting to seasonal trends in catch rates • Reintroducing breeding stock indices into the objective function (after the condition for indicator 1.1.1.5 is met) • Estimating efficiency change within the assessment model • Identifying key uncertainties in assumptions and data and undertaking appropriate sensitivity analyses Issues to be considered include: • Estimating the relationship between puerulus settlement and recruitment within the assessment model • Incorporating size data into the assessment The client shall than provide a report to SCS of the outcome of the review, including an updated 2009 quantitative stock assessment report, based on recommendations and findings of the review. Assuming a satisfactory resolution of the current uncertainties and problems in the assessment, the new assessment model would then be used as the basis for the 2010 assessment and for the provision of management advice for the 2010/11 fishing season. **Timeline:** 8 July 2010	stock. See Review Panel's report in the Appendices of the report on the workshop. **Completed** **Completed** **In progress.** Equation is in the model and is being tested. **In progress.** **Completed** **Completed** **Completed.** This report on the workshop provides the outcomes of the review. The new ITQ model is being used to provide an assessment of the stocks and for the provision of management advice for the 2010/11 fishing season. A preliminary comparison of outputs from the old ITE model compared to the new ITQ model is provided as part of the report on the workshop.	14 July 10 14 July 10

Condition 1.1.5.2 (2009) Uncertainty about future recruitment arising from the collapse in puerulus settlement is dealt with in the projections, but does not (yet) impact on the assessment of current resource (breeding stock) status. As noted elsewhere in this report, key uncertainties that should be dealt with include changes in efficiency of effort, and changes in maturity and catchability affecting breeding stock indices. The confidence bounds presented in the assessment report do not adequately reflect (underestimate) the true level of uncertainty in the assessment. **Note: Condition 1.1.5.1 (2009) above should address the uncertainty in the assessment.**	Some aspects of the model that resulted in underestimations have been addressed in the new ITQ model. Calculations outside the model will be made within it (where feasible and efficient) and sensitivity analyses will be undertaken and reported to provide an evaluation of the uncertainty associated with model structure and data inputs	It is anticipated that most aspects of this work will be completed by the November 10 annual audit
Condition 1.1.5.3 (2009): All future advice by management to RLIAC, the Minister, and stakeholders must include as a routine feature, "best estimates" of stock status and a forecast of effects of management arrangements. At the same time, the advice must also provide a clear indication of the major uncertainties in current assessments and projections. (See Condition to indicator 1.1.5.1). Progress on this Condition will be determined at the next annual audit as it is only possible to judge at the time major (annual) management decisions are made.	This will be completed by the time of the next annual audit in November 2010.	November 10

Condition 1.1.5.5 **<u>Revised Rationale:</u>** The model used for the quantitative assessment of the western rock lobster provides a good basis for evaluating different management options for the fishery and has clearly been useful (and used) to explore combinations of tactical measures to achieve desired catch reductions in the face of concerns about puerulus settlement. However the concerns discussed above about the robustness of the current quantitative assessment also raise concerns about the robustness of the forecasts and do not currently support a high degree of confidence in the adequacy of the harvest evaluation. This indicator clearly meets the first element of the 60 scoring guideline and also meets the second element in the sense that the exploration of management tactics is probably robust to the uncertainties in the assessment. Condition 1.1.5.1 (2009) above will allow this indicator to meet the 80 scoring guideposts.	**Most aspects completed**. See status of 1.1.5.5 above. All aspects will be completed by the next annual audit in November 2010.	November 10

Harvest Strategy and Decision Rules

Condition 1.1.4.2 (2009):

The Client shall provide the CB with clear evidence that the interim harvest strategy and decision rules applied for the 2009/10 fishing season, and intended to be applied for future management of the fishery, have been **formally endorsed by the Minister** and made publicly available.

Timeline: To be completed by March 2010[0].

Condition 1.1.4.4 (2009):

Issue a clarification of what is intended by the elements in the harvest strategy that involve undertaking a review, such that there is confidence that this measure will not be used to delay appropriate management responses, but instead be used to determine the most effective form of management response, within reasonable time frames.

Timeline: To be completed by March 2010[0], as in 1.1.4.2.

A progress report on MSC Conditions 1.1.4.2 and 1.1.1.4 concerning the Harvest Strategy and Decision Rules for the western rock lobster fishery was provided to the MSC's certifying body, Scientific Certification Systems (SCS), on 16 June 2010.

Summary of progress report to SCS

A decision to change to from and ITE[12] management system to an ITQ management system for the 2010/11 fishing season was made after the Harvest Strategy and Decision Rules (HSDR) had been released for public comment. In transition to an ITQ system most of the current input controls (e.g. limitations on pot usage) will be maintained in additional to the ITQs for the 2010/11 season. In the longer term some of the input controls will be removed to allow greater flexibility for operators in the fishery.

As pointed out by the Review Panel, the change to an ITQ[13] management system will require a review and modification of the HSDR, particularly with regard to:

- quota settings (including zone settings),
- targets for catch and breeding stock (BS), and

[12] ITE = Individual Transferable Effort (i.e. each individual fisher has a set number of traps, which are transferable).

[13] ITQ = Individual Transferable Quota (i.e. each individual fisher has a set catch quota, which is transferable).

- more detailed management responses to maintain BS and catch rates at appropriate levels based on MEY principles.

A strategy is currently being developed to progress the review and modification of the HSDR.

The core sustainability element of the current ITE based HSDR, i.e. to keep the BS at safe and sustainable levels projected 4 to 5 years into the future with 75% confidence, will remain fundamental to the new ITQ based HSDR and will continue to be used to determine management settings in the intervening period. An initial evaluation of stock assessments using the old ITE model and the new ITQ model (developed at the review workshop), indicate that the current harvest rate settings and those proposed for 2010/11 and 2011/12 (i.e. annual TACs of about 5,500 tonnes) are appropriate for keeping breeding stocks above their threshold levels out to five years into the future, with a 75% probability. Therefore there is no urgency to develop and implement a new ITQ based HSDR prior to the 2010/11 season.

The Client seeks SCS's advice regarding the Conditions set for the HSDR, i.e. Conditions 1.1.4.2 and 1.1.4.4, noting that the HSDR will need to be reviewed and modified to reflect the change to an ITQ management system.