Preliminary Harvest Strategy

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# Background

The following is an outline of a harvest strategy being developed for the Dafeng crayfish fishery for the Baolong Group processor near Yancheng. The strategy is based on a stock assessment being conducted data collected during the 2018 season. The stock assessment has not yet been completed, so final estimates of stock status, reference points and HCR are not yet available. Nevertheless, the general form of the results is clear, and the analysis has been completed sufficiently to propose a harvest strategy for consideration and discussion for the 2019 season.

# Key Findings

**Observer Data**: The observer data have been found to be very high quality and will be critical for the stock assessment. Patterns in the data are consistent with the species biology and will allow key values to be estimated.

**Purchase Records**: Baolong Group purchase records do not incorporate any measure of fishing effort. Therefore, they are only suitable to calculating the total landings. This is however a very important statistic and will be critical for the stock assessment.

**Logbook Data**: The logbook data have not turned out to be so useful and may need to be re-evaluated. However, the data appeared to improve in 2019, and importantly may be the best way to estimate catches that are not being purchased by Baolong.

**Season Differences**: In 2019, two seasons data were available. These show a different pattern in the data and hence modelling. 2019 was reported as being an unusual year to a typhoon and data collection was curtailed. Because both years are so different, interpretation is very difficult at this stage, and more years data are likely to be required before it can be determined how to improve modelling these data.

# Stock Definition

In general, it is believed that about 20000t of wild caught crayfish are caught in the region per year, with around 18000t in the Doulong river basin and around 6000t purchased by the Baolong plant (i.e. around 30%). However, the Baolong plant purchases the majority of the catch in the Dafeng district around Yancheng. River connectivity between Dafeng and other districts is well-defined and limited to various canals and rivers. For the purposes of the current stock assessment, Baolong purchases will be treated as the total catch for this management unit.

In 2019, whether Baolong provide sufficient coverage was put in doubt because fishing continued after Baolong had stopped purchases. Recording these additional catches will be necessary not only for using the total catch in the stock assessment, but also to evaluate the effectiveness of the HCR.

# Stock Assessment

An age specific depletion model is being fitted to the available purchase and observer data. There is a high probability of success because the data have captured the changes in the population well. The stock assessment will estimate the exploitation rate and the number of females reaching maturity. Because it is only one year’s data, it will not be able to estimate general productivity (e.g. average recruitment or the effect of temperature on production). However, it will be sufficient to propose and test through simulation an interim harvest control rule for the 2019 season.

# Reference Points

Reference points for the fishery will likely be proposed as spawning biomass -per-recruit at 40% (SPR40% target) and 20% (SPR20% limit). Spawner-per-recruit calculations should be possible with outputs from the stock assessment. However, reference points for the HCR will likely be adjusted to the level of acceptable risk of 5%, 10% and 20% probability of the stock falling below the limit reference point and 50% probability being below the target. Reference points were not updated from the 2018 season because the lack of consistency of the data.

It should be noted that the target could be set lower than the precautionary SPR40% to account for the fact this is an introduced species and the fishery may be the main control on population size (MSC CR 2.0 SD2.1.1.2). It is recommended to keep the precautionary target for the moment however due to various uncertainties associated with the data and its interpretation. If the stock status can be estimated more precisely in future, a lower target (SPR30%) may be considered more suitable in this case.

# Harvest Control Rule

The options for a harvest control rule are limited at this stage. It is therefore proposed that a simple rule is introduced as a preliminary control for the 2019 season. The HCR will need to have the attribute that it reduces the harvest rate as the stock approaches its limit reference point.

Effort or catch controls (e.g. TACs) are not an option at this stage and may never be appropriate. Varying the length of the season is the best option at present. Implementation at this stage would depend upon Baolong limiting the date of purchase to an earlier time, if that was found to be necessary. It is important to note that with current controls the fishery is subject to, effectively, a fixed harvest rate policy. This is because the numbers and distribution of traps remains fixed. Agreeing to maintain this harvest policy will form an important part of the HCR. It may be possible that a stock assessment will make recommendations on this target harvest rate, but this is not likely to be the case from the first assessment. Nevertheless, it is important to be aware that if the current harvest rate exceeds the SPR20%, it may be difficult to justify against MSC requirements and the first assessment may indicate a reduction in harvest rate is necessary.

As well as a current harvest rate, the HCR will define a trigger point when further harvest reduction would be required. Crayfish are inactive earlier in the season, so earlier start than customarily applied is not a threat to the fishery. Hopefully, this reduction would only be required in unusual circumstances, and the HCR would not affect the normal operation of the fishery. A trigger point should be determined based on some measure of abundance. For the preliminary HCR, the trigger point would be determined by the catch rate. In future as more data become available, a more sophisticated approach could be developed. Effectively the fishery would be closed (Baolong cease purchases) in the week following the point when average catch rates have fallen below some value determined from the stock assessment.

The proposed harvest control rule will have several parts:

1. The season will start in week 1 (at the end of April or beginning of May)dependent on when Baolong begins purchasing crayfish. This will be determined by Baolong based on their custom practice.
2. Harvest within the management unit will be limited to registered permit holders with the current number of traps within their harvest areas.
3. Catches will be taken with standard traps: the management authority will be notified of any changes to gears or fishing operations.
4. Harvest will cease on or before **14 August** each season.
5. Harvest will cease within the season if the average catch rate determined each week falls below **X** kg/3 traps.

The values in bold need to be determined and may be adjusted. **X** needs to be estimated using stock assessment output. The practical implementation of any HCR (who carries out the monitoring, data processing, calculations etc.) will also need to be decided.

# Monitoring

The harvest control rule will require monitoring data. For the next 1-2 years, this will depend upon the observer data as were collected in 2018. It will need to be determined how monitoring will be conducted in the long term. The most cost-effective way would be to change either the logbook data or purchase records to obtain the required data for the HCR. A reduced observer programme could also be implemented in the long term, with the significant advantage that the sizes of crayfish would also be recorded.

A significant data gap is the total catch. 2019 was apparently an unusual year with a typhoon causing Baolong to end its purchases early. It was reported however that many fishers continue to collect and sell crayfish in other markets. This has two implications:

1. Catches were incomplete. Catches not purchased by Baolong need to be estimated. Logbooks can be used for this, but the catches reported in logbooks will still need to be raised to the entire fishery. This might be done now by estimating the raising factor comparing logbook catch to total purchases by Baolong during the season. The validity of this approach will need to be discussed and/or verified. Other raising factors (e.g. number of registered traps) could also be used, and the best approach chosen through consultation.
2. When Baolong stopped purchases, the decrease in landings provides an indicator of the effectiveness of the HCR tools to reduce exploitation. Currently it is assumed that when Baolong ceases to purchase crayfish, this would act as a strong disincentive to continue catching crayfish. It is as yet unclear whether this was the case in 2019.

# Further Work

See Appendix 1 for a summary of performance relative to the MSC requirements based on work I have completed. This can be updated.

A priority for the 2020 season will be to make further improvements to the data collection system. Specifically, there is a need to estimate total catches not purchased by Baolong and ensure that the observer data are collected throughout the season even if Baolong stops purchases, when fishing continues, or if Baolong delays starting purchases, but fishing has started. The logbooks seem the best way to provide information on catches sold to other buyers than Baolong, and it should be ensured that they capture this information.

It will be possible to conduct further stock assessment work which can be used to support the harvest strategy. Apart from improving the data collection as outlined above, the following tasks could be undertaken.

* Evaluate the use of alternate covariates in explaining catch rates. These would likely be temperature and water flow. Initial work on this could be carried out now, but it would likely be more productive to wait at least until after the 2020 season when another year’s data would be available. This is important because catch rates are used to monitor abundance and are therefore used in the HCR. The reasons for changes in catch rates other than abundance need to be explored.
* Conduct a length-based assessment excluding catch and effort data. Using only the size composition, it should be possible to obtain an estimate of fishing mortality for comparison with SPR40%, SPR30%, and SPR20% levels. Size composition data is the most reliable data available. If considered urgent (e.g. MSC full assessment is to take place before 2020), this could be carried out now, but may also be more likely to be successful if undertaken if necessary in 2020.

# Appendix 1

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| **ID** | **Name** | **SG60** | **SG80** | **SG100** | **Comments** |
| 111a | Stock status relative to recruitment impairment. | It is **likely** that the stock is above the point where recruitment would be impaired (PRI). | It is **highly likely** that the stock is above the PRI. | There is a **high degree of certainty** that the stock is above the PRI. | There is currently no evidence that the stock is overfished. The apparent abundance was much higher in 2019 compared to 2018. It is highly likely that the stock is above its PRI.The target is not clearly defined yet, although the stock status appears with any candidate target reference points at this stage. |
| 111b | Stock status in relation to achievement of Maximum Sustainable Yield (MSY). |   | The stock is at or fluctuating around a level consistent with MSY. | There is a **high degree of certainty** that the stock has been fluctuating around a level consistent with MSY or has been above this level over recent years. |
| 121a | Harvest strategy design | The harvest strategy is **expected** to achieve stock management objectives reflected in PI 1.1.1 SG80. | The harvest strategy is responsive to the state of the stock and the elements of the harvest strategy **work together** towards achieving stock management objectives reflected in PI 1.1.1 SG80. | The harvest strategy is responsive to the state of the stock and is **designed** to achieve stock management objectives reflected in PI 1.1.1 SG80. | With the monitoring programme in place, the harvest strategy is being evaluated. However, data are as yet insufficient to allow full evaluation.Elements are licensing system and limits on traps, opening and closing of season and Baolong purchasing arrangements. Furthermore, there is a well-defined rule that should reduce catches if the stock is determined too low.There are potential gaps in the system. Catches not sold to Baolong, and environmental effects undermining the HCR assumptions may prevent the strategy achieving PI 111 objectives. |
| 121b | Harvest strategy evaluation | The harvest strategy is **likely** to work based on prior experience or plausible argument. | The harvest strategy may not have been fully **tested** but evidence exists that it is achieving its objectives. | The performance of the harvest strategy has been **fully evaluated** and evidence exists to show that it is achieving its objectives including being clearly able to maintain stocks at target levels. | Evidence is currently insufficient to show that the harvest strategy will work. See stock assessment report for suggestions on further actions that can be taken before 2020. Another year’s data should help test the strategy. |
| 121c | Harvest strategy monitoring | Monitoring is in place that is expected to determine whether the harvest strategy is working. |   |   | The current monitoring system should be adequate to evaluate the harvest strategy. |
| 121d | Harvest strategy review |   |   | The harvest strategy is periodically reviewed and improved as necessary. | No review has been conducted as yet. A review could be completed alongside a technical review of the stock assessment. |
| 121f | Review of alternative measures | There has been a review of the potential effectiveness and practicality of alternative measures to minimise UoA-related mortality of unwanted catch of the target stock. | There is a **regular** review of the potential effectiveness and practicality of alternative measures to minimise UoA-related mortality of unwanted catch of the target stock and they are implemented as appropriate. | There is a **biannual** review of the potential effectiveness and practicality of alternative measures to minimise UoA-related mortality of unwanted catch of the target stock, and they are implemented, as appropriate. | In general, crayfish are unharmed during capture. Undersized and berried crayfish are returned alive, otherwise crayfish are retained. It is unlikely that this PI will need to be evaluated. |
| 122a | HCRs design and application | **Generally understood** HCRs are in place or **available** that are **expected** to reduce the exploitation rate as the point of recruitment impairment (PRI) is approached. | **Well defined** HCRs are **in place** that **ensure** that the exploitation rate is reduced as the PRI is approached, are expected to keep the stock **fluctuating around** a target level consistent with (or above) MSY, or for key LTL species a level consistent with ecosystem needs. | The HCRs are expected to keep the stock **fluctuating at or above** a target level consistent with MSY, or another more appropriate level taking into account the ecological role of the stock, most of the time. | The main task is to ensure the stock remains above its limit reference point, and the precautionary HCR should continue to ensure that this is the case.There is a strong environmental component affecting the population and the fishery.It may be argued that the target stock size should be lower than MSY since the species is introduced. |
| 122b | HCRs robustness to uncertainty |   | The HCRs are likely to be robust to the main uncertainties. | The HCRs take account of a **wide** range of uncertainties including the ecological role of the stock, and there is **evidence** that the HCRs are robust to the main uncertainties. | The HCR has undergone preliminary tests using projections of the Bayesian stock assessment. These are probabilistic in nature and show the HCR should be robust in reducing exploitation levels if the stock size falls below a preliminary precautionary level. |
| 122c | HCRs evaluation | There is **some evidence** that tools used **or available** to implement HCRs are appropriate and effective in controlling exploitation. | **Available evidence indicates** that the tools in use are appropriate and effective in achieving the exploitation levels required under the HCRs. | **Evidence clearly shows** that the tools in use are effective in achieving the exploitation levels required under the HCRs. | It is not clear yet that the tools in place are sufficient to reduce substantially the exploitation rate when required. Currently, it depends on plausible argument that catches will decrease when Baolong stops purchases. This still needs to be verified.  |
| 123a | Range of information | **Some** relevant information related to stock structure, stock productivity and fleet composition is available to support the harvest strategy. | **Sufficient** relevant information related to stock structure, stock productivity, fleet composition and other data are available to support the harvest strategy. | A **comprehensive range** of information (on stock structure, stock productivity, fleet composition, stock abundance, UoA removals and other information such as environmental information), including some that may not be directly relevant to the current harvest strategy, is available. | Information is sufficient to support a preliminary harvest strategy considering the size and scale of the fishery. Information is set to improve over time. |
| 123b | Monitoring | Stock abundance and UoA removals are monitored and **at least one indicator** is available and monitored with sufficient frequency to support the harvest control rule. | Stock abundance and UoA removals are **regularly monitored at a level of accuracy and coverage consistent with the harvest control rule**, and **one or more indicators** are available and monitored with sufficient frequency to support the harvest control rule. | **All information** required by the harvest control rule is monitored with high frequency and a high degree of certainty, and there is a good understanding of the inherent **uncertainties** in the information [data] and the robustness of assessment and management to this uncertainty. | Total catch, CPUE and size composition are collected through the season. These data should be sufficient to support an HCR. |
| 123c | Comprehensiveness of information |   | There is good information on all other fishery removals from the stock. |   | Not all catches are estimated. Whereas in 2018 unrecorded catches were not considered significant, in 2019 they may have been. |
| 124a | Appropriateness of assessment to stock under consideration |   | The assessment is appropriate for the stock and for the harvest control rule. | The assessment takes into account the major features relevant to the biology of the species and the nature of the UoA. | The HCR is constructed to be consistent with the stock assessment and available data. However, recent testing suggests that further data and development may be required due to inconsistent results between the 2018 and 2019 seasons.  |
| 124b | Assessment approach | The assessment estimates stock status relative to generic reference points appropriate to the species category. | The assessment estimates stock status relative to reference points that are appropriate to the stock and can be estimated. |   | The stock assessment evaluates stock status relative to reference points. |
| 124c | Uncertainty in the assessment | The assessment **identifies major sources** of uncertainty. | The assessment takes **uncertainty into account.** | The assessment takes into account uncertainty and is evaluating stock status relative to reference points in a **probabilistic** way. | The stock assessment is using Bayesian model which is probabilistic. |
| 124d | Evaluation of assessment |   |   | The assessment has been tested and shown to be robust. Alternative hypotheses and assessment approaches have been rigorously explored. | Although the stock assessment has been tested, it is not clear that it is robust. Significant uncertainty remains on environmental effects and how these might be accounted for. |
| 124e | Peer review of assessment |   | The assessment of stock status is subject to peer review. | The assessment has been **internally and externally** peer reviewed. | The stock assessment has not been peer reviewed. recent testing suggests that it is not yet ready for review. |