9. ParFish – Participatory Fisheries stock assessment

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9.1 INTRODUCTION
The ParFish approach provides a framework for participatory stock assessment and co-management. In this approach, fishers are actively involved in the management process, and their knowledge may be incorporated into stock assessments alongside more conventional fisheries data. As illustrated in Figure 9.1, the ParFish approach begins with guidance on understanding of the context (Step 1) and setting objectives (Step 2). It then goes on to provide tools and techniques for data collection and stock assessment (Step 3) and to support communication of the results to the stakeholders and the development of management actions (Steps 4 and 5). The final stage (Step 6) is to evaluate the ParFish process to provide feedback and guide future management efforts.

The final outputs of the ParFish process can include:
- improved fisher understanding of the concepts of fisheries management;
- greater involvement of fishers in the management process; and
- agreed management options including control levels, monitoring plans and pilot schemes.

Although ParFish is being developed by the FMSP as a general co-management system, this section looks in detail at Step 3, how the stock assessment is carried out within this participatory framework. More detailed information on the other steps will be provided in a toolkit, and the software manual will provide step-by-step guidance on carrying out the analysis. These tools will be made available shortly at http://www.fmsp.org.uk/.
9.2 BACKGROUND

Small scale fisheries require agreement and co-operation to achieve management objectives. Methods that rigorously capture stakeholder knowledge, objectives and preferences have been generally unavailable in fisheries. However, these are now recognized as being of central importance in establishing successful management.

Although meetings among fishers using participatory approaches can produce better co-operation, any decisions made still need to be informed by scientific advice regarding the status of the fisheries resources, and the consequences of following different management alternatives. The absence of good advice balancing risks and benefits may lead to overfishing and economic hardship. In this context, science can be seen more as a form of independent arbitration among fisher opinions, not as a way of dictating management decisions.

Bayesian statistical methods are particularly well adapted to dealing with situations where there is a lack of good scientific information, because they deal with uncertainty in a consistent and rigorous manner. Existing assessment methods often demand detailed time-series of catch and effort data. Expensive data collection activities are inappropriate for many small scale fisheries, and collecting many types of data is often beyond the capability of countries operating under severe financial constraints. While these data should be used where they are available, their absence should not prevent stock assessments and management advice.

A participatory stock assessment method has been developed to address these needs. It applies Bayesian decision analysis, using non-parametric robust statistical techniques and interviews implementing a multi-attribute decision-making method. The analyses can be conducted using specially written software.

ParFish applies standard stock assessment models, but uses new techniques and methods to make the assessment more flexible. The ParFish approach has four distinct differences compared to other approaches:

• The fishing community’s views can be incorporated into the stock assessment by using information gathered through interviews. Even if these beliefs are considered unreliable, there is considerable political advantage in involving fishers in an assessment where they can see that their views are being taken into account. It is arguably necessary if co-management is being applied.

• Data can be combined from many sources, and in particular, rapidly collected data can be used as a starting point for an adaptive management system.

• The method applies decision analysis, making use of utility (a measure of the stakeholders’ preference for an outcome) and risk to help in deciding management actions. This means the method can be used to give advice even when only limited information is available.

• The method can use any information source as long as information can be reduced to frequencies of possible parameter values for a target simulation model. A number of Monte Carlo techniques are available for producing such frequencies. Separating sources also allows information to be built up from simpler sub-models, making the whole process easier.

9.3 OVERVIEW

The ParFish method allows complex information sources to be organized into a hierarchy describing a target fishery model that is then used to assess fishery controls. Controls are assessed on the basis of the changes in catch rates that they are expected to produce in the fishery over time. Fishers are separately asked to rank and score possible outcomes on their catch and effort in terms of their preference, thereby allowing the assessment to identify the control yielding the greatest preference score. Altogether, this allows information from many sources to be combined, and in particular involves fishers and their community in the stock assessment process.
Information on the fish stock state and behaviour is reduced to sets of parameter frequencies. The parameters are defined by the target simulation model that is thought to represent the possible projected behaviour of the fishery. As long as information can be reduced to a frequency of one or more of these parameters, it can be used in the model.

Parameter frequencies may be generated in a number of ways, including direct draws from a probability distribution (e.g. Markov Chain Monte Carlo), interviews and empirical bootstrapping. The last two are supported within the software. However, complexity in data interpretation often requires non-standard models which generally cannot be supported in simple software. Therefore the software also supports the loading of previously-generated frequencies from Microsoft Excel.

Current components which are supported in the software consist of:

- An interview to get subjective belief from fishers or other persons with relevant knowledge.
- The use of fishing experiments and non-destructive survey methods (such as visual census).
- The use of any catch-effort based stock assessment models and data.

Any number of such frequencies can be combined to produce a posterior probability density function. Sets of parameters can then be repeatedly drawn at random from this posterior and used in the target simulation model to project changes in catch and effort in response to different controls.

Each outcome, a catch effort time series, is converted to a utility score using the relative preference information from the fishers. By ranking and scoring these scenarios it is possible to estimate how much better or worse a fisher would think any particular outcome is compared to the present.

One or more variables under management control must have been identified which have an impact on the objective. For example, in many fisheries the numbers of fishers or fishing days could be limited, whereas catch could not. Fishers or fishing days would be the appropriate control variable. Possible controls are limited to closed area, and catch and effort controls in the current software.

The target and limit reference points are defined in terms of the management control (the action to be taken by management) and should be chosen to be consistent with the management objectives. The main objectives currently supported by the assessment methodology are:

- To maintain fishing so that the probability that the biomass falls into an overfished state is at a particular level. The definition of “overfished” is defined by the limit state, and would be set to 50 percent of the unexploited biomass in most cases. The probability is a measure of management’s risk averseness policy.
- To move fishing activity to a target level of fishing which has the highest expected preference for the fisher community based on the current uncertainty (the “Bayes action”). Management may change issues such as whether and how they weight fishers’ opinions. They may also set a policy discount rate.

It is important to note that the optimum decision is not the same as a prediction for the outcome. The prediction is represented by the probability distribution, which may be very uncertain. The method chooses the optimum action based on this uncertainty, so if the decision-makers are risk-averse, actions are taken that will tend to avoid the worst outcomes rather than just assume the expected outcome.

9.4 THE TARGET SIMULATION MODEL

Simulation models are used to provide management advice through investigating the effects of applying different potential management controls. A target simulation model must be chosen that represents the behaviour of the fishery, and in particular, its expected response to changes in catch and effort.
The chosen model needs to adequately describe the dynamics of the system and be able to give indications of what might happen under any particular management regime and how this might affect fishers. These predictions can be used to provide management advice.

A fishery will be made up of a number of parts, such as species, fishing grounds, gears and fishing communities. Each fishery should, ideally, have a model developed specifically for it. However, it is pointless trying to use more realistic models unless significant amounts of information are available. Simpler models which encapsulate basic biological behaviour will probably be more accurate in data poor situations.

As the focus in ParFish is fisheries with limited data, a robust simple model was chosen as the starting point for the analysis and as an easy way to introduce fishers to population dynamics. The software currently supports only the logistic (Schaefer) biomass dynamics model, which has simple attributes common to all biological systems. It describes biomass growth and allows estimation of a surplus yield which will not deplete the population.

9.5 CONTROLS

9.5.1 Effort
The effort control is applied through the catch equation used in the simulation model. A new effort is set as the new control and the stock is projected forward from its current state under the new fishing mortality.

9.5.2 Catch quota
The catch quota control is applied as a future limit to catches. A new effort must also be supplied as the maximum effort. This is used to calculate catches. If catches exceed the quota, this maximum effort is scaled back to a level where the catches are met. This allows effort to change, but catches remain fixed if the effort is high enough to reach it and if the stock is not overfished. Setting the quota above the MSY means it will have no effect and the maximum effort control will apply.

9.5.3 Refuge
Management can provide a refuge from fishing by setting up closed areas or no take zones. Such zones may provide many benefits beyond those dealt with in this assessment model, and each of these benefits may be sufficient to justify a closed area. The model considers only the impacts on the fish stock and the resulting catch and effort.

The refuge control indicates what proportion of the stock is protected from fishing. The stock is initially split into protected and unprotected stock in proportion according to the control and it is assumed that there is no adult migration between the two. Migration would reduce the effective refuge size. The two separate stocks are modelled independently. If there has been no previous refuge, both stocks will be at the same level. Once the control is applied the protected stock will rise to the unexploited level. The exploited stock will be subject to the new mortality based on a new effort level defined for this control. The unexploited stock size and the recruitment between the refuge and exploited areas is split according to the control level.

Catch is only removed from the exploited part of the population, although both parts contribute to overall recruitment and growth. This will result in an immediate decrease in catches after the control is introduced and effectively a decrease in catchability. There is a longer term gain in stock size as productivity is boosted by the refuge stock. As the model suggests, refuges are a good way to maintain the stock size above the limit reference point. In combination with effort control, refuges could provide a useful tool for reducing risk.
9.6 CONTROL REFERENCE POINTS

Indicators must be converted to measures of preference, so that risks can be properly assessed. For example, fishers may wish more to avoid low catches rather than make large catches, and hence be risk averse. This requires that indicators be converted to some measure of utility (an economic measure of satisfaction).

The target simulation model calculates the overall catch and effort for the fishery projection. These can be converted to the relative change in CPUE and effort. These relative changes are assumed to apply equally to all fishers, so that if CPUE is 85 percent and effort 80 percent of the initial CPUE and effort, then each fishers CPUE is also 85 percent and 80 percent of his/her current CPUE and effort. The main assumption is that any effort or other control is applied proportionally to all fishers.

The optimum Bayesian decision is to choose the action that maximizes the expected preference. Using the preference data and model (see Section 9.9), the discounted preference score can be summed for each simulation leading to a relative measure of how much that outcome would be preferred. The expected preference score is the average of the simulations where the simulation parameters are drawn at random from their posterior probability distribution.

The maximum is found by interpolating between the control increments using a polynomial function. Finding the maximum by direct means would be very slow and produce an unnecessary degree of accuracy. If greater accuracy is required, the range of the control (minimum – maximum) can be reduced around the optimum point and/or the number of control increments can be increased.

The limit reference point is designed to limit the chance of overfishing to some acceptable level. Overfishing is defined here as forcing the stock biomass below some limit state defined as the proportion of the unexploited biomass. The limit state may be set by the user, but there is a generally accepted point for some models, most notably MSY at 50 percent for the logistic/Schaefer model. The probability of reaching this state is calculated as the chance that a scenario state taken at random from all scenario states combined over time, species and simulations, is below the limit state. This position is found again through interpolation using a polynomial function. The method, as well as working for the current simulations, will work with stochastic simulation models or under more complex management simulations. It could also be interpreted as the expected proportion of time that stocks will spend in the overfished state under each management regime.

9.7 PROBABILITY ASSESSMENT

The ideas for the approach for modelling probability originate with Press (1989), who presented a method to estimate the probability of nuclear war. Nuclear war is similar to overfishing in that we do not want to have several observations before being able to estimate if and how it might occur. Press (1989) suggested using interviews with experts and kernel smoothing functions to generate a prior probability. The approach can easily be extended to dealing with very many other sources of information.

Given a set of frequency data, how can a probability density function be obtained? One option would be to fit a parametric distribution. This would require knowledge of the appropriate shape of the function. While in some cases we would be able to propose a function, such as the normal or log-normal, in many others it would not be possible. There is always a risk of proposing an incorrect function and introducing structural error. Instead, a more general non-parametric technique using kernel smoothers is used.

Kernel smoothers provide the building block for probability density functions. Silverman (1986) provides a detailed description of the use of kernel smoothers in estimating densities in one dimension. This method has been adapted to multiple dimensions. The method is essentially construction of a smoothed form of histogram.
Instead of adding each point to a bin, each point is spread over the real line to smooth the distribution.

There are two requirements to this method. Firstly, a kernel function must be chosen. It has been shown that the particular choice of function is not particularly important in trying to estimate a density (Silverman, 1986), so the function can be chosen more for convenience than mathematical requirements. The normal or Gaussian function was chosen for the current model for two reasons:

- The multivariate normal offers a simple way to calculate and maintain individual multidimensional kernel models through use of its covariance matrix. In particular, the posterior of a normal mixture can be calculated directly.
- Where very little data is available from interviews, for example, the normal distribution has a natural shape which it is assumed can represent an individual’s subjective prior as well as building into a community density function once enough data are available.

The second requirement is a smoothing parameter for each dimension which controls the degree of spread of the density around each point in the frequency. These parameters are important. Not only do they change the look of the density, but it is a measure of the uncertainty associated with each point in the frequency and hence the frequency as a whole.

Each probability density function is represented by a smoothed probability distribution around a set of points. The points can be derived from interview (see Section 9.8.3), and represent the prior belief of interviewees (expert stakeholders/fishers), from bootstrapping a stock assessment model fitted to fisheries data (see Section 9.8.1) or from other means. Frequencies are smoothed by spreading the probability around each point using the normal kernel function (Figure 9.2).

**FIGURE 9.2**
An example of two points forming a mixture distribution in one dimension. The individual smoothed point densities (---) are added together to produce a joint density (---). In the top graph, the smoothing parameter (Sigma parameter or standard deviation in the normal distribution) is large and a single flattened mode is produced. In the bottom, the smoothing parameter is relatively small and produces two modes.
Although several frequencies (information sources) might be used, they must be independent. Non-independent parameter estimates must occur within the same frequency, so that their dependence can be represented by the way they occur together. The separate independent smoothed frequencies can be combined to generate a posterior probability density function.

Using frequencies has several advantages and disadvantages:

1. A complex set of parameters can be broken down into simpler subsets which can be assessed separately.
2. Gross errors can be minimized as each set can be checked separately to ensure estimates are reasonable. For example, catch and effort models might be fitted in the normal way, and the observed – expected plots inspected to ensure the fit is reasonable. All other standard checks can be applied to ensure results are valid.
3. The method can be made robust. Non-parametric techniques can be used to obtain frequencies.
4. Given a set of parameter frequencies, computation of the posterior is straightforward, fast and exact.
5. The individual probability density function derived from the frequencies may be inaccurate. If each smoothed frequency represents the source probability density function exactly, the corresponding posterior distribution is also known exactly. However, any inaccuracies between the individual kernel models and the underlying probability density functions will be represented in the posterior. These inaccuracies will have two sources. Firstly a randomly-drawn frequency will contain errors both in precision and bias (precision can be increased through increasing the number of random draws). Secondly, the smoothing parameters will be estimated with error. These parameters allow the kernel to cover regions between the frequencies, but also they will provide the relative weight between information sources.

9.8 MODELS FITTED TO DATA

9.8.1 Approach

Fitted models are structured as a linked hierarchy of sub-models. The structure allows greater flexibility, speeds up the fitting process and will allow easier development in future.

The basic structure is to have a multispecies model at the top level (if appropriate), the single species population models next and then generalized linear models which fit to data. There can be many species populations for each multispecies model and many generalized linear models for each single species model. The generalized linear models (GLM) link the population models to observations. The population models are more likely to be non-linear and more difficult to fit.

The separation of the single species model and GLM is a formal, more integrated approach of what is already commonly done (see Hilborn and Walters, 1992; Lassen and Medley, 2001). In many cases, a GLM is applied to observations to produce a population index. The population index is then used to fit the population model. While this pre-processing may be easier with some complex data sets, it introduces a redundant parameter and ignores possible correlations between the GLM and population model parameters. McCullagh and Nelder (1989) provide a description of generalized linear models as implemented in the current software.

The basic approach is to include the population size as a variable in the GLM. For any set of population parameters, the GLMs can be fitted to the population sizes. This is fast even if a GLM contains many parameters. A slower non-linear minimizer can then be used to minimize the fitted GLM log-likelihood with respect to the smaller number of population parameters.

The GLM approach in the software allows three types of log-likelihood: Normal, Poisson and Log-normal. The default is the Poisson. The quasi-likelihood argument
(see McCullagh and Nelder 1989) suggests that, at least for the GLM parameters (as opposed to the non-linear population parameters), only the variance-mean relationship needs to hold to obtain maximum-likelihood estimates. Finally, the software allows parameter frequencies to be loaded directly, so any external model can be used to generate parameter PDFs as required.

An empirical bootstrap method is applied to generate parameter frequencies. This is the same methodology as applied in the CEDA software (Section 4.5). The approach has been found to be robust and is widely used in stock assessments as a measure of uncertainty. The interpretation in ParFish is a little different, however, as the resulting frequency is assumed to approximate the parameter likelihood.

9.8.2 Population models
The logistic (Schaefer) model fitted to the data is the same as that used in the target simulation model and CEDA software. This model is the simplest closed population model encapsulating recruitment, growth and density-dependent mortality. It describes the basic behaviour of populations.

The parameters are given maximum and minimum limits to prevent unrealistic results. The current population state, $B_{now}$, is defined as the estimated total biomass at the current time as a proportion of the unexploited stock biomass and therefore varies between 0 and 1.0. The intrinsic rate of increase ($r$) produces erratic behaviour above 2.0. Estimates above 2.0 indicate a shorter time unit should be used. The unexploited biomass must be above the maximum observed total catch in any time period. An upper limit was also placed on the unexploited biomass, at 100 times the maximum total catch. This upper limit is set because if catches do not discernibly decrease the resource size (1 percent mortality probably would not), the resource size estimate can become arbitrarily high. If the estimate drifts to this upper level, we will learn little more than that the resource is lightly exploited. No boundaries are applied to the catchability parameters which are fitted through regression.

A linear depletion population model is also provided for analysing fishing experiment data. This assumes a closed population with changes only coming about through catches and natural mortality. The model is useful for estimating catchability and the current biomass within the area of the fishing experiment, which may then be scaled up to the total area and size of the overall stock.

9.8.3 Stock assessment interview
The interview allows the logistic model parameters to be estimated from information provided by fishers by asking them key questions which can be related to the current state of the resource and its potential yield. Questions are asked in units and terms familiar to the fisher. The following information is obtained from each fisher:

- the main gear used, last year’s CPUE and this year’s CPUE for that gear;
- the current CPUE for all other gears used;
- the expected catch rate range for the unexploited stock; and
- the time for an overfished stock to recover to the unexploited state.

In addition, the total effort in this fishery over the last year has to be obtained from elsewhere (e.g. from Department of Fisheries’ data, personal estimates or key informants in the fishery). The total size of the fishery should form the frame of the sample and allows the individual answers to be raised up to the totals for the whole community.

The individual catch rates are regressed towards the mean of the sample. This is necessary as they are used as an estimate for the mean catch rate for the whole fishery although the question asks for the fisher’s own catch rate.

There are considerable political benefits from taking account of fishers’ views, but it is not clear how valuable this interview information is in terms of assessing the stock. A positive example of the use of this approach is given in thr Box below.
BOX 9.1

Testing the ParFish approach in the Turks and Caicos Islands

The queen conch fishery in the Caribbean Turks and Caicos Islands provides a useful test of the value of fisher interviews because a long time series of catch and effort data is available for comparison. The fishery consists of small vessels that go out for day trips only. The 2 or 3 crew free dive up to 10m depth to collect conch which are shelled at sea. The meat is landed at the processing plants which keep a record of the vessel, date and amount purchased. These data are used for calculating the catch and fishing effort.

Effort in the fishery has fluctuated naturally over the years as available labour has responded to economic conditions. This has given enough contrast in the time series to get a good fit from a logistic biomass model (Medley and Ninnes, 1999).

The fishery is managed through a quota, so this is the appropriate control. Using the preference information, the stock assessment based upon both the interview and catch-effort model combined and the catch-effort model alone suggest a quota of around 1.53 and 1.38 million pounds respectively. Interviews by themselves were found to be much less accurate (as indicated by the much lower limit control), but nevertheless recommended a target of 1.68 million pounds, reasonably close to but above the other targets.

If it is assumed that fishers knew as much in 1974 as they do now, the interview data can be used as representative of a sample that would have been obtained had the interviews been conducted at the beginning of the time series. Hence, the interview-only target quota can be applied at that point to see what might have happened to the fishery had this stock assessment method been applied, assuming that the logistic and maximum likelihood parameter estimates are correct.

The actual total catch over the period 1975–2002 was 45.47 million pounds. Had the 1.68 million pound quota been applied, the results suggest a total catch of 47 million pounds. This quota would realize higher catches in the longer term by foregoing catches in the late 1970s. A discount rate of around 5 percent yields approximately the same net present value between the two options.

The real gain, however, would have been the rise in catch rate (Figure 9.3). The catch-effort model suggests the stock was in an overfished state in 1974 and an enforced quota would have led to stock recovery. In other words, the catch would have been met with much less work and costs than has been applied (from 3 300 boat days down to 2 500 boat days to realize the same catch). This case study suggests that there are considerable benefits to be made using just interview data if no other data exist about the fishery. This would need further testing to make the case as a general statement. However it is clear that an initial quota set on the basis of interview, but updated as other scientific information came available would have led to much better economic benefits from this fishery over the last 30 years.

<table>
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<tr>
<th>Scenario</th>
<th>Target Control</th>
<th>Limit Control</th>
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<td>1 580 855</td>
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<tr>
<td>Catch-Effort Model Only</td>
<td>1 384 882</td>
<td>1 432 696</td>
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TABLE 9.1

Target and limit controls (landings quota in pounds meat weight) for the Turks and Caicos Islands Conch fishery based on catch-effort and interview data
Economics in fisheries assessments have mostly been dealt with by assessing costs and prices and constructing an economic model of the fishery profit. This is probably the best way to assess commercial fisheries, although it has problems:

- Such assessments are expensive and could not be extended to each small scale fishery,
- Data may be inaccurate and fishers may be unwilling to co-operate,
- There may be unobserved variables connecting data to utility (for risk etc.),
- The non-commercial aspects of fishing are not accounted for.

For small scale fisheries, a direct approach is more appropriate. In this case, the assessment tries to identify the situation fishers would prefer, so that managers can try to target this. This may not directly lead to greater understanding of the economics of the fishery, but should give the fishers the opportunity to select management targets more similar to their own needs or priorities.

Obtaining information on preferences for outcomes in the fishery has several significant advantages for small scale fisheries:

- It is simpler and faster to assess potential changes in the fishery.
- It is probably more robust to consider changes directly. This does not require an accurate model of the economics of the fishery, but does require fishers to be able to assess how changes in catch and effort might affect them.
- Asking fishers their preferences among outcomes gives them power over management objectives, but still allows independent scientific advice to make a contribution. This is consistent with all the advantages of community based management.

The cost of applying the quota is that, without the depletion in the mid-1980s, less information would now be available on the behaviour of the stock, so that the current stock assessment would be less reliable. This would need to have been addressed through alternative research activities.

**FIGURE 9.3**

Expected catch per boat day (CPUE) from the fitted logistic model and the projected CPUE with 1.68 million pound quota.
The questions make fishers think more clearly about possible outcomes for the fishery. If community management is to be successful, it is important fishers understand possible management outcomes and can weigh up the impact of these on themselves and the community. This assessment approach not only obtains data for assessment, but starts fishers thinking about what might happen and what they would prefer to happen.

A main disadvantage is that it is left to the fisher to assess and balance complex issues. However, although imperfect, fishers are probably the best at assessing their own circumstances and the effect of changes in the fishery and will get better with practice.

The main source of error is the fishers’ inability to assess accurately how they might react to changes in the fishery. This is exhibited in the narrow choice offered in scoring (see below) as fishers were unable to finely discriminate between outcomes. This error would probably decrease with practice.

A second source of error is in the way the utility model is used. The utility is averaged over respondents, so all are assumed to react in the same way, that is reduce or increase their fishing or catch by the same proportion. In practice, each individual will react separately to maximize their own utility. This makes the assessment pessimistic and the community utility curve will be flatter than that suggested in most assessments. It is unclear whether the maximum point would be much affected by this issue.

The general method can be extended in future based on the hierarchical model structure. For example, the overall catch variable can be calculated as the weighted average of the changes in individual species. The more important a species is to a fisher the higher the weight this species catch gets in the utility model.

9.9.2 Preference interview

Although utility theory is well defined and methods for practical utility estimation are available (Keeney and Raiffa, 1993), they need considerable adaptation and simplification to be used for assessing fishers’ utility. Not only does the method need to be simple to understand, it has to be rapid to allow a broad cross-section of the community to be represented and to avoid interview fatigue.

Simplification is achieved by:

- The variables examined are simple and consistent. The assessment focuses on catch (earnings) and effort (work done).
- Comparisons are made as relative changes from the present situation.
- Scenarios representing changes from the present situation are ranked, then the difference between them scored. The total score for each scenario is the cumulative sum of these scores.
- The number of comparisons are minimized as “dominance” was automatically taken into account in the method.
- All comparisons are “pairwise”, so fishers only have to consider two scenarios in any comparison.
- Interviews are based on households as the fundamental economic unit.

It is worth noting that standard utility and multi-attribute decision making techniques have been tried. These techniques were not found to be suitable for fishers in the context of the interview, because they require sophisticated interviewees who have a clear understanding of the issue and are prepared to spend considerable time building up the information necessary to support the method. Such methods are useful in analysing decisions, and this is probably the primary way they are used in decision-making. This analytical capability could be re-examined as a tool to help a small group of fishers representing the fishing community come to some decision on the community’s behalf.
9.9.3 The catch-effort scenarios

Scenarios represent possible changes in the catch and effort as they relate to the fisher. Changes are represented as +/-25 percent steps relative to the present and are constructed to maximize the information obtained for a regression information matrix. The scenarios, which have been given a letter for easy identification, can be laid out in relation to the current catch and effort (scenario I in Figure 9.4).

One scenario will dominate another where it is clearly better. If we assume higher catches for the same effort is always better and higher effort for the same catches is always worse, any scenario where the catch is higher than or equal and effort is lower than or equal to another scenario will always be preferred. For example, O will always be preferred to I, as catch is higher and effort is the same. These dominance relationships can be used to rank all 17 scenarios more rapidly with the fewest number of comparisons. A represents the best, and C the worst scenarios, so it is only necessary to place all other scenarios between these two.19

It should be pointed out here that the individual fisher’s preference to maximize his or her own CPUE may not be consistent with the community or policy preference which may be to maximize employment. With the latter goal, options N and even E may be preferable to A.
9.9.4 Scoring
The score for each scenario is calculated as the cumulative sum of the difference scores between the ranked scenarios. The scores between ranked scenarios are additive, as they are assumed to measure the relative distance along a utility line. So, by ranking and then asking for a score as an indication of preference between consecutive scenarios (0 – no difference, 4 large difference), all scenarios can be scored.

There are a few useful assumptions which can be made about catch and effort utility curves. Firstly, the curves are monotonically increasing for catch and probably mostly monotonically decreasing for effort. The effort curve is less certain as some fishers complained they would become bored if they could not fish at least some days per month. Given the interest in sports fishing, this does not seem unreasonable. Secondly, they are bounded at zero as fishers would never go fishing if they did not expect to catch something, so utility should never fall below the point where they stop fishing altogether. The CPUE or catch at which they abandon fishing should set the lower bound on the utility.

There are also upper limits to the utility curve. There are logistical limits to the amount of catch that can be handled and the effort which can be applied. Excluding religious days, the number of days fishing a month is probably limited to 25. The amount of fish which a vessel can handle is likewise limited. Changing these limits, such as employing more crew or purchasing larger vessels would change the nature of the fishery and hence the assessment would have to be undertaken again.

9.9.5 Errors and feedback
If the results from the preference assessment are used without feedback to the interviewee, results may not accurately represent true preferences. By their very nature, questions are abstractions and may draw out abstract or inconsistent answers. The way to avoid this is to present back to the interviewee the implications of their answers which they can adjust interactively.

The rank order provides a method to check consistency of replies. Basically, the interviewer can check the reasoning of the fisher for the order chosen. Originally this was intended to see whether a fisher understood the object of the exercise and perhaps exclude those that did not. In practice, consistency was used as a tool to help fisher understanding rather than test for it.

Firstly, dominance is assumed and used in ordering the scenarios. However, fishers should be given the opportunity to change this order. Secondly, the fisher’s current activity can be assumed to be optimum. So, the scenarios with the same catch rate but fishing more or less than now are presumed to be less preferred than the current level of catch and effort. If it is not, the fisher should be able to explain why not. The aim was to get the fishers to think as clearly as possible about what the scenarios would mean to them in reality.

The method works through contrasting catch and effort variables and forces the fisher ranking the scenarios to define an exchange rate between them. Whereas the ranking works well, it was less certain that the scoring was as accurate. Scoring nevertheless gives the fisher the opportunity to draw a distinction between small and large differences between scenarios.

9.9.6 Preference model
The additive nature of the scoring technique suggests that a quadratic model of each variable together with a single interaction term should be adequate in modelling the score (Figure 9.5). The model interpolates the score and smoothes through errors. Pure interpolation is too sensitive to errors. As an alternative to the interview preference, a simple linear price-cost function is also provided in the software.
Example preference curves fitted to interview data (points). In cases of point outliers, the interviewer could check with the interviewee that the scenarios are in the right order. They may also be evidence that the model is too inflexible for good individual curves.

FIGURE 9.5
Preference score

Preference score