Social and Environmental Research Institute

Lobster Catch and Price Model User Manual

System Dynamic Model for Exploring Lobster Fishing Scenarios

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Introduction

Model Scope

The Lobster Catch and Price Model has been designed to simulate the expenses, catch, and income made by any given lobsterman fishing any given unit area. The model allows the user to compare various alternative scenarios to a business as usual model. It thus provides the opportunity to visualize how the outcomes of lobster fishing will change should the timing of trapping efforts be altered, what happens when ecological changes alter the timing of lobster molting, and what new trapping policies would mean for the lobsterman's bottom line. The purpose of this tool is to promote understanding of changes as well as discussion. No model is capable of taking an absolutely complete account of all of the variables in a complex system. However, the Lobster Catch and Price model includes the major factors that determine outcome, thus giving the user insight into the relative changes to outcomes that will occur when inputs are varied. The goal of using this model should not be to make precise predictions upon which to base lobstermen's household budgets, for example.

Gathering data and refining outcomes will be an iterative process, ideally. Once initial inputs have been estimated and a first round of outputs obtained, it is best to use the results to encourage further conversation. In what others ways might efforts be changed to maximize rewards and minimize efforts? Are there ways in which the subject of a particular model might economize on fuel or bait? Would it be worthwhile to forego fishing entirely at some point in the year? Questions such as these will lead to investigations that are unlikely to occur during the first round of data collection. Dialogue is the key to maximizing the usefulness of this model.

Technical Requirements

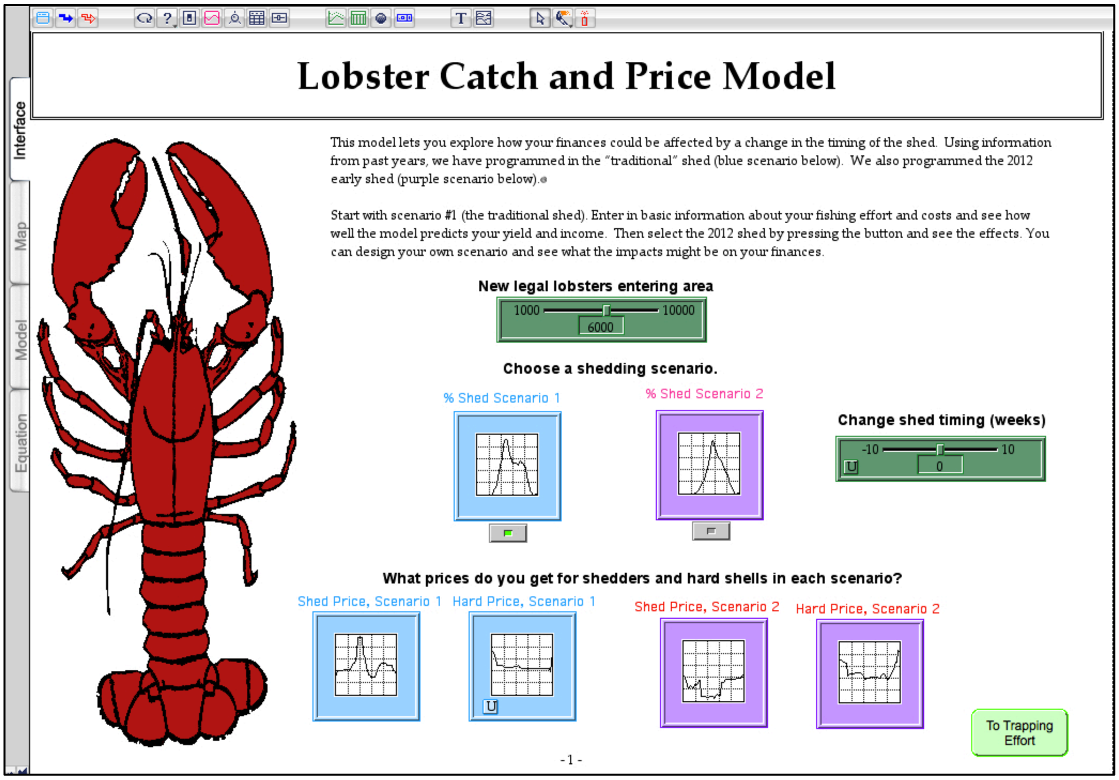
The Lobster Catch and Price Model will run on both Windows and Apple platforms. It has been created using isee systems' STELLA software. In order to run it, the isee Player must first be installed. Versions of the player for either Windows or Apple can be downloaded free of charge from http://www.iseesystems.com/softwares/player/iseeplayer.aspx. The isee player allows the user to see, but not to edit, both the user interface and underlying model elements. Editing can only be done with the full version of STELLA, which can be purchased at http://www.iseesystems.com/softwares/Education/StellaSoftware.aspx. This is not necessary for typical use of the model.

Data Collection

A variety of inputs are needed to run the model. Precise numbers are ideal but estimates will provide useful information when the model has been run. The better the estimates, the more realistic the outputs will be. Be aware that estimates of the number of traps hauled each week, pounds of lobsters caught, weekly expenses (i.e., fuel and bait), annual expenses (boat payments, insurance, equipment maintenance, etc.), and price per pound for sheds and hard lobsters will be required. The value of providing respondents with appropriate and easy-to-use instruments for data collection cannot be overstated. Default data is included in the model, all of which can be changed to create any number of unique scenarios to explore.

User Interface

Panel 1: Shedding Scenarios and Prices

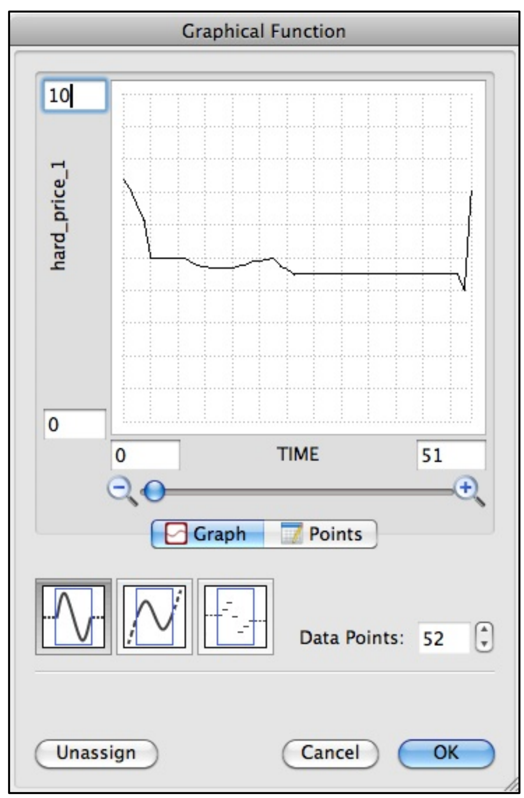


In Panel 1, you will enter the number of new legal sized lobsters entering the fishing area at the beginning of the year. By default, the slider will be set to 6000. As it is not possible to determine precisely the number of new legal lobsters entering a lobsterman's fishing area, you may need to experiment by adjusting the slider repeatedly to get results that match real data. Panel 1 also comprises two Shed Scenario graphs. % Shed Scenario 1 is intended to represent the typical timing of lobster molting over the course of a year. % Shed Scenario 2 charts an unusual early molting scenario recorded in 2012. As with all of the graphic inputs, other than Yearly Expenses on Panel 4, these two graphs represent change on a weekly basis over the course of a year.

Next to the two % Shed Scenarios is a slider that allows the user to shift the two graphs in time by up to 10 weeks. Negative numbers indicate the shed beginning earlier in the year. Positive numbers move the shed later.

Associated with each of the two % Shed Scenario graphs are two pricing graphs, one for shed price and one for hard price. These allow for the user to chart the predicted price for each type of lobster as it changes during the year. Click the button below one of the graphs to select it. The button beneath the selected graph will turn green. **Be aware that clicking on one button does not automatically deselect the other; you must click on a green button to deselect it manually**.

To change any of the graphs throughout the interface, double click on it. This will open an input dialogue box open such as the one shown below. Once you have opened the input dialogue box, you can change the input graphically by clicking and holding with the cursor over the graph line. If you wish to enter precise numbers simply click on the points option below the graph and you will have the ability to enter a numeric value for each week. Note that the independent variable on this graph, as on all graphs in this model, is time in weeks. The

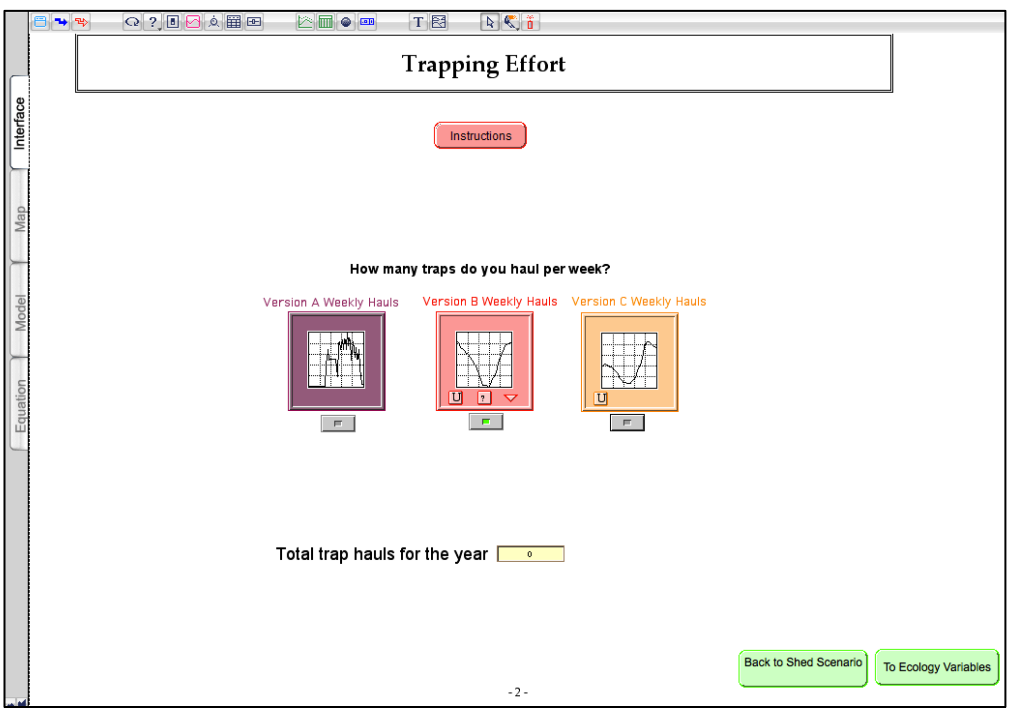


dependent variable in this case is a price between $1 and $10 per pound. On other graphs, this may be the percent of the lobster population shedding, a price for bait, or any number of other variables. All graphic inputs in this model work the same way. Once you have appropriately adjusted the % Shed Scenarios and their associated price per pound, click the button in the lower right corner to move to the next panel, Trapping Effort.

Panel 2: Trapping Effort

Trapping Effort

This panel is where data on the number of trap hauls per week over the course of the year is entered. The scenarios encompass both actual effort and any limits placed on the number of trap hauls per week by changes in policy. Three graphic inputs, Version A, Version B, and Version C weekly hauls are shown:

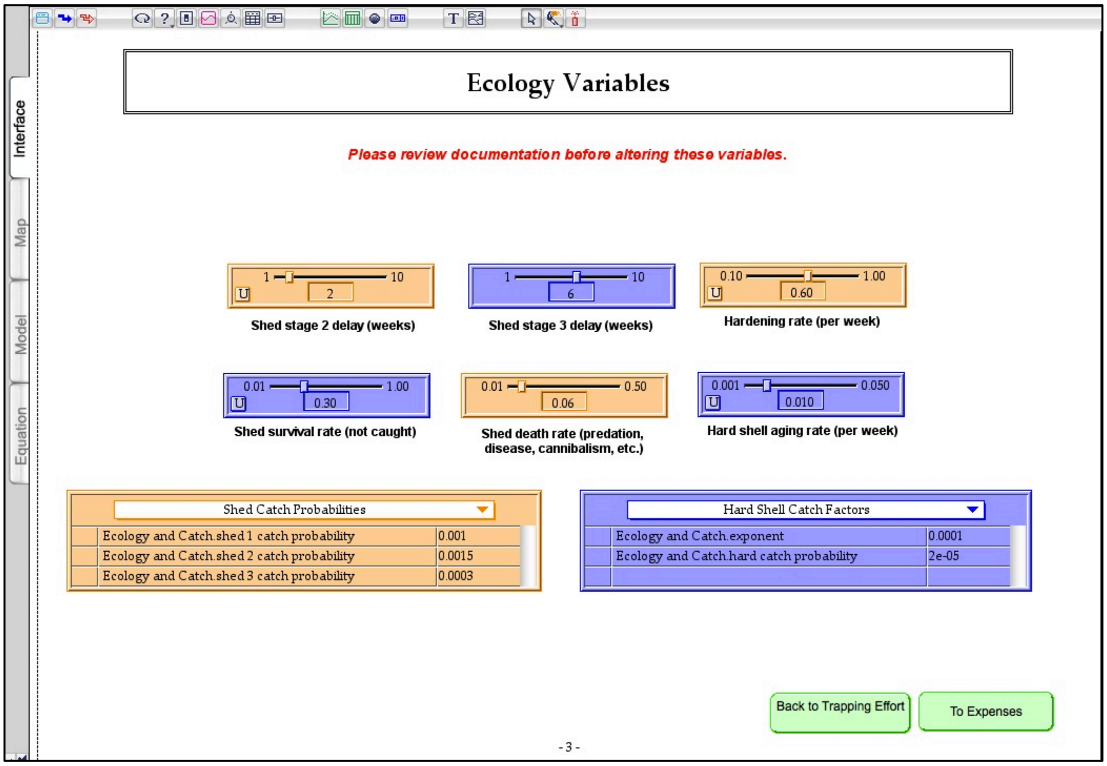


Version A Weekly Hauls represents business as usual. Version B and Version C Weekly Hauls represent alternatives. By default, Version B represents a scenario in which most fishing occurs at the beginning and end of the year. Version C is a scenario in which the trapping effort increases mainly at the end of the calendar year. As was the case with the shedding scenarios in Panel 1, any Weekly Hauls scenario may be changed by double clicking on the graphic input and altering the graph line or numeric data points. Again, **make sure that you are selecting only one of the three scenarios before running the model**. Only one of the buttons, the one below the Weekly Hauls scenario you wish to run, should be green.

Also on this panel is a numeric display of the total number of trap hauls per year. This will almost certainly vary with the Weekly Haul scenario that you select. In total, this panel represents annual trapping effort varying according to policy, work, and the number of traps owned by a given lobsterman. When you have satisfactorily entered the Trapping Effort data, you can choose one of the buttons in the lower right corner to either return to Panel 1 (shedding scenarios) or go on to enter ecology variables in Panel 3.

Panel 3: Ecology Variables

This panel allows the user to adjust a number of variables within the model that fine tune the results. Small changes to them can lead to significantly different outcomes, so it is important that the user comprehend their meaning and interplay. Once these have been adjusted, the user can opt to either return to the Trapping Effort panel or advance to the Expenses panel.



Shed Stage Delays and Hardening Rate

The first two sliders in this panel control the time required to pass from shed stage 1 to shed stage 2 (Shed stage 2 delay) and from shed stage 2 to shed stage 3 (Shed stage 3 delay). These are arbitrarily defined points in the hardening process, from initial molting to the point at which a lobster is reasonably considered to have a hard shell. Hardening then continues at a weekly rate determined by a number of factors, such as temperature and nutrition. These can be varied to experiment with effects in changes in conditions that affect hardening once the model has been calibrated. In nature, hardening continues until molting again takes place the following season. The hardening rate, like all ecological variables in the model, is measured in weeks. Setting this slider to 1.00 therefore indicates that lobsters are fully hardening in a single week, a very unlikely scenario.

Shed Survival Rate

This is simply the rate at which lobsters with still-hardening shells elude traps and any other factors (see below) that remove them from the population. Obviously, it is necessary that some sheds survive to become hards. If this were not the case, the population would collapse.

Shed Death Rate

This is the rate at which all pressures other than fishing remove shed lobsters from the population. While not being trapped, these lobsters are not surviving to become hard shells. Pressures that contribute to the death rate include, but are not limited to, predation, disease, and cannibalism.

Hard Shell Aging Rate

The hard shell aging rate is a measure of how quickly hard shelled lobsters within the population grow enough to exceed the upper limit on legal catch size. They can be thought of as those individuals that have survived fishing and other causes of death long enough to outgrow economic usefulness to lobstermen.

Shed and Hard Catch Probabilities

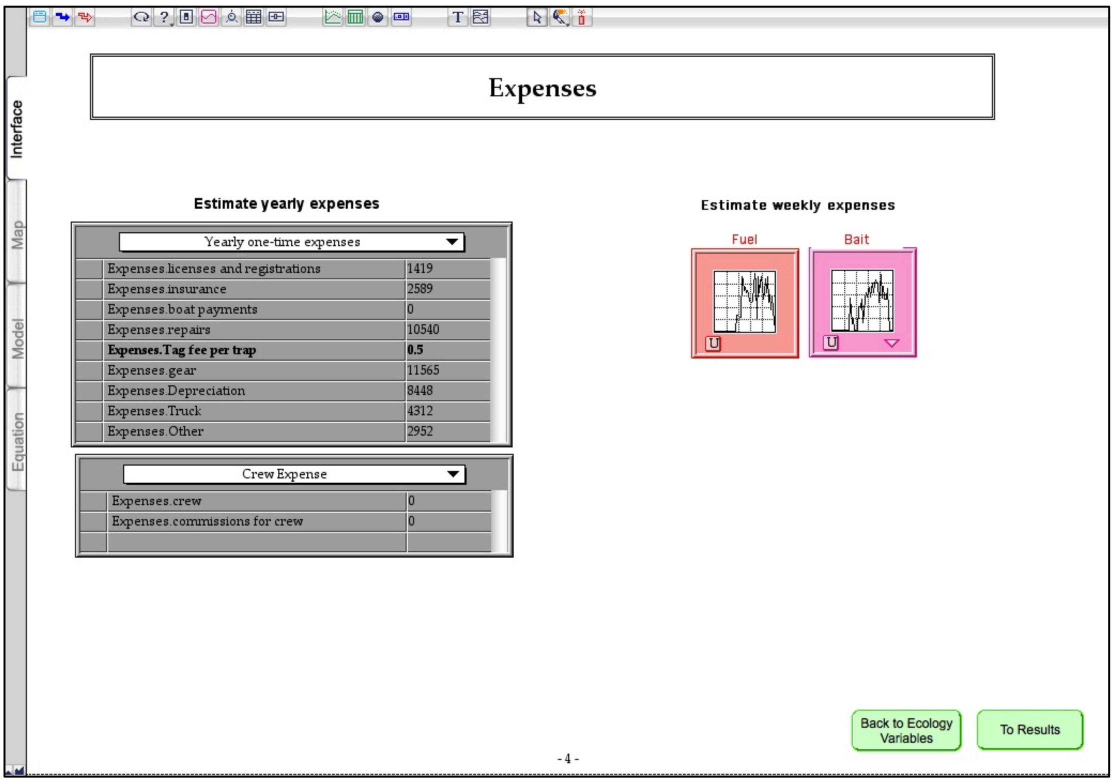
In the tables at the bottom of this panel you will see catch probabilities for each of the shed stages and for hard shell lobsters. All of these are very small numbers that can create big changes in the outcomes of your model, so be sure that you understand them before making adjustments to these values.

Each of these numbers represents the probability of a single lobster in the fishing area entering a given trap. Because these probabilities can be affected by a significant number of factors beyond what we can know with certainty, including population density, water depth and temperature, type of bait used, local predation, etc., it will be necessary in most cases to change them for each data set when calibrating the model with real data. We suggest strongly that you only change these numbers after you have entered all other variables and run the model once. If you have entered the other data correctly, the differences between the outcome of the model and the outcome in the real data are due to the catch probabilities.

Catch probabilities should remain small and in all likelihood will not change in magnitude from the default values. Keep in mind that each catch probability is dependent upon preceding catch probabilities. Intuitively, the more likely a lobster is to be trapped at shed stage 1, the less likely it is to be trapped at shed stages 2 and 3. Also in the Hard Shell Catch Factors table is the variable **exponent**. As the word implies, this controls the rate of change for the exponential function that approximates the likelihood of trapping a hard lobster due to the initially unknown population density of hard-shelled lobsters. Like the catch probabilities, this should be adjusted conservatively when necessary to calibrate the model against a data set.

Due to the probabilistic nature of all of these variables, it may require several attempts to adjust them adequately for model calibration. You will know that you have the correct when the income figures, numbers of hards and sheds, and the proportion of sheds to hards is close to that in your calibration data.

Panel 4: Expenses



This panel comprises three types of expenses incurred by lobstermen. First, there is a table of Yearly one-time expenses, such as boat payments and repairs. Below this is a table for Crew Expense. Finally, there are two graphic inputs for weekly expenses, namely fuel and bait.

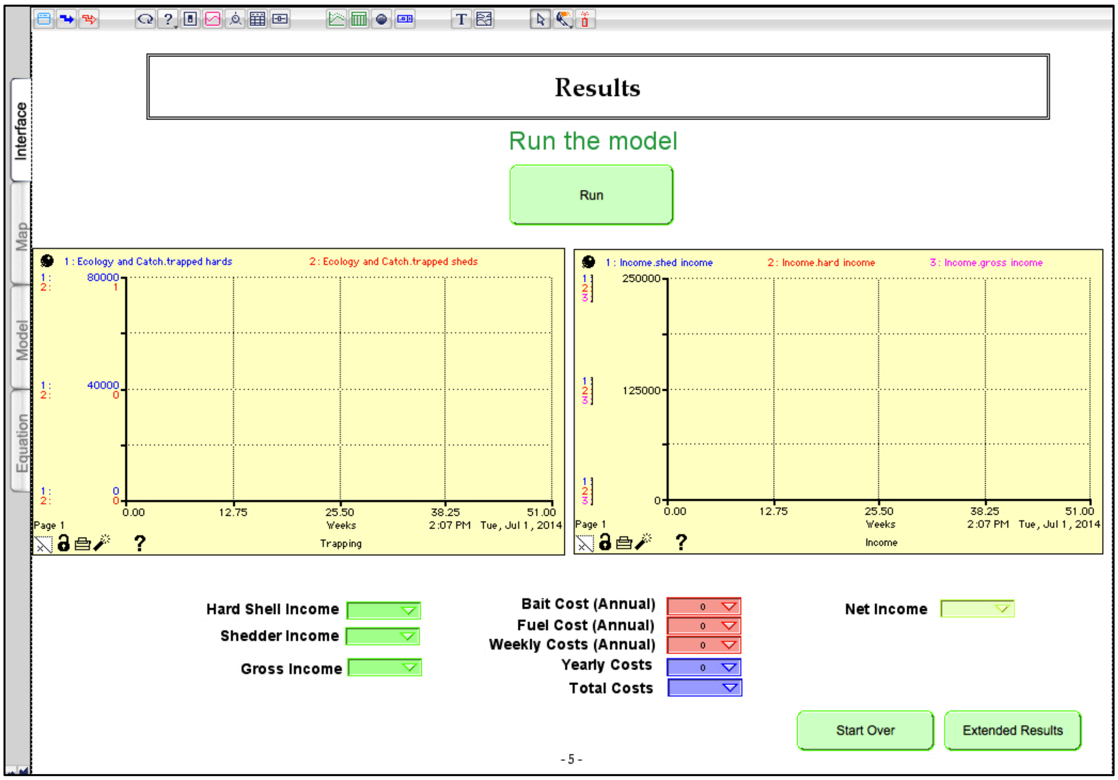
To enter a value into the yearly expenses tables, double click on the cell in the right column. The cell turns white, at which point you can enter your datum. Note that you cannot use arrow keys to scroll down to the next cell; you must double click to change a cell each time. You may find that a lobsterman does not have one of the yearly expenses. For example, he may be done making boat payments or he may not pay crew commissions. If this is the case, enter 0 for the amount of that expense. If there are annual expenses not covered elsewhere, add them as Expenses.Other on the line provided at the end of the 'Yearly one-time expenses' table.

The Fuel and Bait weekly expenses work like other graphic inputs, as noted above (see Panel 1). Double click to open them, then click, hold and drag to change the line. Alternatively, you may choose to enter numeric data by selecting the points option.

Once you have entered all data in Panel 4 and are satisfied that you are ready to obtain results, proceed to the Results panel. Otherwise, you can choose to go back to a previous panel.

Panel 5: Results

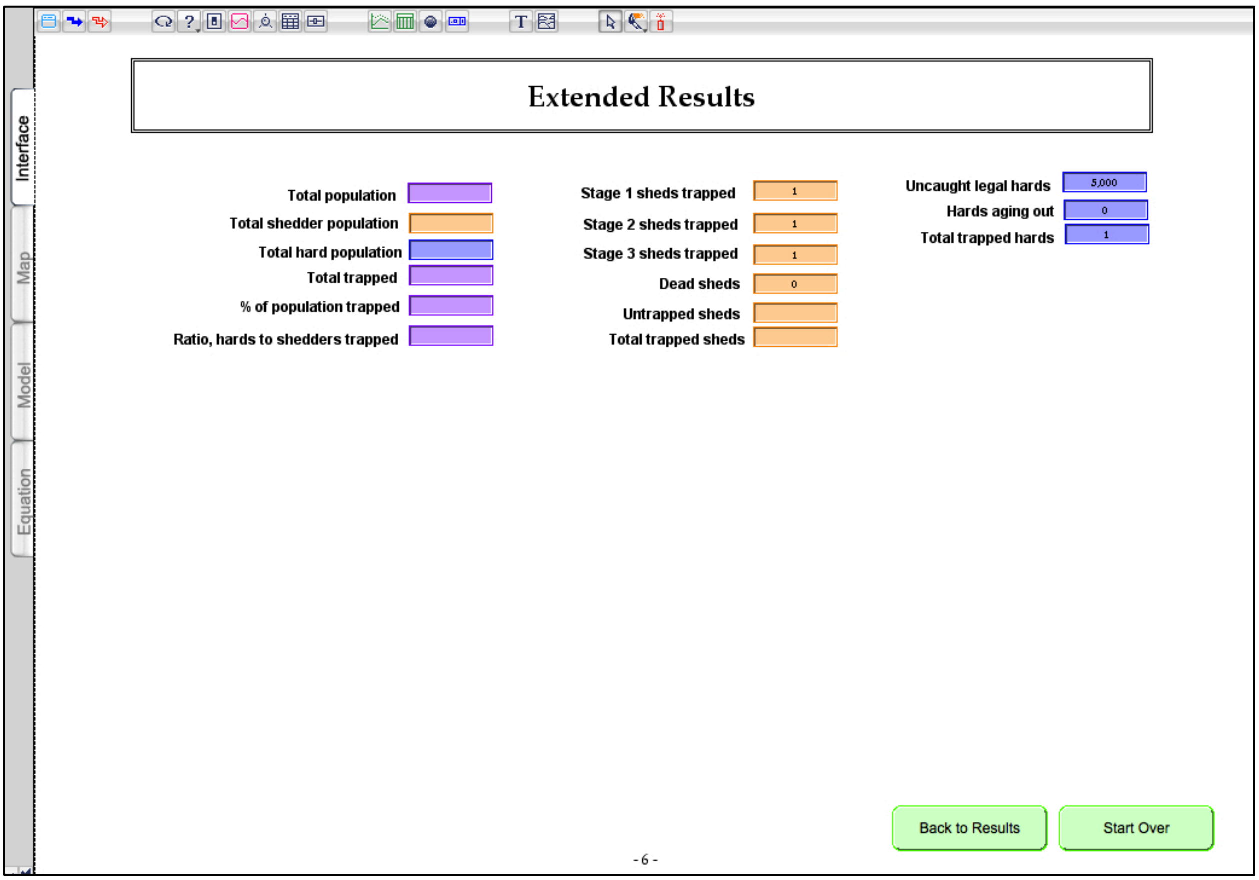
Click the run button at the top of this panel; you will see the results of the scenario you have created in the previous panels. There are two graphic outputs here. The first charts the pounds of hard and shedder lobsters caught during the year. The second graph illustrates shed, hard, and gross incomes. In some cases, the values obtained for the dependent variables graphed may be so different that STELLA will automatically provide two sets of values on the graph's y-axis. When this happens, the values shown on the axis will be of the same color as the dependent variable title at the top of the graph. You should keep this in mind when comparing your scenarios.



Hard, shed, and gross incomes are also shown in numeric displays in the left column below the graphs. The middle column of numeric displays highlights expenses. The year's summed weekly expenses for bait and fuel and the total of the two are given in the red displays. One-time yearly costs are summed in the purple display below the red weekly costs. At the bottom of the middle column, the weekly and yearly costs are summed to give total costs for the year. The sum of all costs is subtracted from the gross income and the balance is shown in the right column below the graphs as net income.

If you wish to explore additional scenarios, click the button labeled 'start over' in the lower right corner. This will take you back to Panel 1 to begin a new round of data entry. Otherwise, you should now proceed to the Extended Results panel.

Panel 6: Extended Results



The final panel displays granular results not visible in the prior Results panel. The first column provides information on the overall lobster population. Most of these entries are self-explanatory, but two merit special attention.

- **% of population trapped** should generally give a result close to 85% when you calibrate the model. This is based on a standard assumption that this represents the proportion of the population caught legally by lobstermen in a given area.

- **Ratio, hards to shedders trapped** is very useful in calibrating the model. The result that you obtain here should be close to the ratio in your data set.

If these two extended results are comparatively far from ideal, it is an indication that you need to adjust the variables elsewhere in the model. In particular, pay attention to the number of new lobsters entering the area (Panel 1) and to the assumptions you have made in setting the ecological variables on Panel 3. The latter are particularly useful for fine-tuning your calibration until the bulleted results above are very close to real world observations.

The middle column delivers extended information on the fates of sheds in your scenario. The Total trapped sheds display should match as closely as possible the data at hand. If it does not, you will likely need to alter the catch probabilities on Panel 3.

The final column represents a breakdown on the fate of hard shell lobsters in the scenario you have created. As is the case with Total trapped sheds, the Total trapped hards should match your real data for calibration purposes. If it does not, once again examine your assumptions in Panels 1 and 3. Keep in mind that there should always be some number of uncaught legal hards and hards aging out after your scenario has run; these are the breeding stock for future generations of lobsters. Obtaining zeroes in these two displays indicates either a problem with your model or a fishery potentially on the verge of collapse.

Additional Capabilities

STELLA software and the isee player provide numerous capabilities for further analysis of your results. One that you may find particularly useful is sensitivity analysis. You may set up a sensitivity analysis by selecting 'Sensi Specs…' under 'Run' in the menu bar. If you require help with this or other STELLA options, select 'Help' on the menu bar. This will open the robust online help system maintained by isee Systems.

Modules and Assumptions

Important Note About Entering Data

The following sections will explain the structure and assumptions of the model. While such a behind-the-scenes look is useful in working with the Lobster Catch and Price Model, **always enter your data via the user interface when an input is available there.** If you make changes directly to the various stocks, flows, and converters without corresponding changes to the user interface, your results will not be correct. STELLA is set up to prioritize changes to the user interface over changes to the back end of the model. This is a peculiarity of the program itself and cannot be accommodated by the model itself. Whenever you calibrate or forecast with the model, **always be certain** that any changes you make are reflected in the user interface.

Shedding Scenario Module

The purpose of this module is to investigate the effects of changes in the timing of molting on the outcomes of lobster fishery practices. It provides the ability to compare two scenarios. Shed scenario 1 shows a typical annual molting cycle, with a large peak approximately halfway through the year and a second, smaller peak in several weeks later. The default setting for shed scenario 2 is an atypical, single-peaked molt cycle that occurred in 2012. Each scenario represents the percent of the legal sized lobster population beginning to molt during a given week.

Each scenario has a shed timing converter that can be altered via the graphs on the user interface. Doing so will change the overall graph shape. It is also possible to shift the timing of each graph by up to ten weeks utilizing the 'timing shifter' converter. Doing so will move the peaks in time by the same amount in both scenarios. For most purposes, the overall shape of shed scenario 1 should not be altered as it is the norm to which changes are compared. Changes will most commonly be made to the shape of shed scenario 2. Changing the graph shapes means fundamentally changing the proportion of the lobster population beginning to molt during the weeks for which alterations are made.

Changing the timing of one scenario will automatically change the timing of the other by the same amount. The assumption in this case is that comparisons regarding shed timing alone require the same temporal shift to both scenarios.

The Shedding Scenario module provides outputs that change the Effort, Pricing, and Ecology and Catch modules. It does not have inputs from any other module.

Pricing Module

This module is used to track the amount paid to fishermen for pounds of legal lobsters throughout the year. This price is expected to fluctuate due to market forces, including availability of hard shell or shed lobsters, throughout the year. Which pricing scenario is chosen is determined by the choice of 'shed ecology' in the Shedding

Scenario module. The pricing scenarios are among the determining factors for the Income module.

Effort Module

As the name suggests, this module is useful in comparing scenarios for catching lobsters of legal size. Up to three scenarios can be compared simultaneously. The amount of effort by a lobsterman is summarized here as 'trap hauls.' The outcome in regard to the numbers of shed or hard shell lobsters caught is conditioned by the inputs provided from the Shedding Scenario module. For purposes of this model, it has been assumed that the number of hauls made per week represents fishing policy, such that changes to policy would be reflected by changes in the weekly hauls. Scenarios are determined by altering the graphical inputs in the user interface. Only one weekly haul scenario should be run at a time and then compared to the other two scenarios as required.

When a scenario is run, the total trap hauls for the year is calculated automatically. The output from this module, Effort, acts as an input for the Ecology and Catch module. Therefore, it is expected that alternate scenarios will be reflected in changes both to lobster ecology (e.g., catching a lot of early shedders means fewer hard shells later) and catch (e.g., if most of the lobsters were caught at the beginning of the season, there would not be many caught at the end of the season).

Ecology and Catch Module

This module is essentially the engine that drives the entire model. It is the most complex and contains a number of stocks, flows, and converters that can cause a great deal of change to model outcomes due to relatively small changes to the variables.

You may have noticed that nowhere in this model is the size of the fishing area explicitly required for calculations to be carried out. For our purposes, the size of the lobster population in the area is what concerns us. This in turn is driven by the number of lobsters of legal size entering the area as new sheds per week throughout the year. The number of lobsters entering in this fashion is controlled by the 'debut' converter, the input for which appears in the user interface. It is also conditioned by shed scenarios from the Shedding Scenario module.

It is assumed that all new sheds will harden at the same rate. While hardening is an ongoing process that only ends when a new round of molting begins, it is useful to envision stopping points along the hardness spectrum at which populations can be tallied. In this module, that is reflected by three 'shed stage' and one 'legal hards' stocks. The timing between the three shed stages can be varied to reflect environmental changes that alter the points at which the stages are reached. By default, it requires two weeks to pass from shed stage 1 to shed stage 2, as set by the 'harden stage 1' converter. Six weeks are required to pass from shed stage 2 to shed stage 3 ('harden stage 2' converter). Changing these two delays will impact the composition and number of the total annual catch. Once lobsters have reached shed stage 3, it is assumed by default that 60% of them per week will qualify as legal hards for market purposes. This rate can be changed by altering the 'harden rate' converter. Furthermore, 1% of the legal hard population is assumed to exceed market size per week, as determined by the 'aging rate' converter. Once this happens, they pass to the 'too old' stock and are not included in catch numbers.

Each of the four stages in the hardening process carries with it a different probability for lobsters in that stage to be trapped, and so halted in the maturation process. The probability associated with each stage is given by a 'catch probability' converter. Each such converter assumes that lobsters having reached a particular stage will pursue food more or less aggressively than at some other stage, that catch rates for each stage is conditioned by factors like water temperature, depths of trapping, and types of baits used, among many others. It is also assumed in this model, based on empirical observation, that the number of hards caught is an exponential function. This necessitated the inclusion of an 'exponent' converter to carry out calculations. All of these converters will likely vary with every data set and so are useful in calibrating the overall model when other considerations have been taken into account. **When calibrating, it is a good idea to save changes to these converters for fine-tuning.** They have significant impacts not only to overall catch numbers, but also to forecasting a correct proportion of sheds to hards in the outcome. This proportion is reflected in the 'trap hard v trap shed ratio' converter.

This model further assumes that not all legal sized lobsters that begin the hardening process survive until its end. A fraction of shed every week is assumed to die due to disease, starvation, predation, and other causes. This fraction is determined by the 'shed death rate' converter and the number of casualties contained in the 'dead sheds' stock. Finally, a number of sheds will survive lobster season without being caught. The number that do so is given by the 'uncaught sheds' stock.

The net lobster ecology combined with the overall effort determined in the Effort module combine to determine the number of lobsters trapped at each stage of the hardening process. These numbers are reflected in four stocks, three 'sheds trapped' stocks and one 'trapped hards' stock. The total number of trapped sheds and trapped hards provide input to the Income module.

Expenses Module

This module serves as an accounting for all of the costs involved with being a lobsterman. These are divided into three categories: recurring weekly costs, crew commissions, and annual one-time costs. Weekly costs are summed to give annual totals in the 'weekly costs' stocks. These are added to the total yearly expenses and crew commissions in the 'all expenses' converter, which in turn serves as an input to the Income module.

There are a number of annual one-time expenses that, in reality, might not come in one lump sum. For instance, insurance is often paid in installments and repairs might well be needed more than once per year. For the model, however, they are covered by annual expenses because they tend not to be weekly. All such non-weekly expenses should be included in the annual expenses. If no other suitable input is available for an expense, include it as 'other.'

Income Module

The Income Module can be thought of as the bottom line for a lobsterman. It is here that the incomes derived from the number of shed and hard lobsters is calculated by multiplying the amounts caught weekly by the fluctuating market prices over the entire year. These two incomes are summed to calculate the gross income. Expenses are subtracted from gross income to determine the net profit realized due to effort conditioned by ecology and market forces. It is here that all of the variables throughout the model are translated to dollars and cents for fishermen, and the impact of changes to the variables can be demonstrated as changes to profits and losses.