Kraken Visualization Tool (KVT)

For visualizing and understanding the secondary effects of predation or predation and competition

See how to install and run below

The purpose of the KVT is to demonstrate differences in biomass and catch estimates when predation and/or competition for prey is taken into account. The model has 10 economically important New England stocks grouped into four categories, or stock complexes:

- Elasmobranchs (skates and spiny dogfish)
- Small pelagics (Atlantic herring and Atlantic mackerel)
- Groundfish (cod, haddock, and redfish)
- Flatfish (windowpane flounder, winter flounder, and yellowtail flounder)

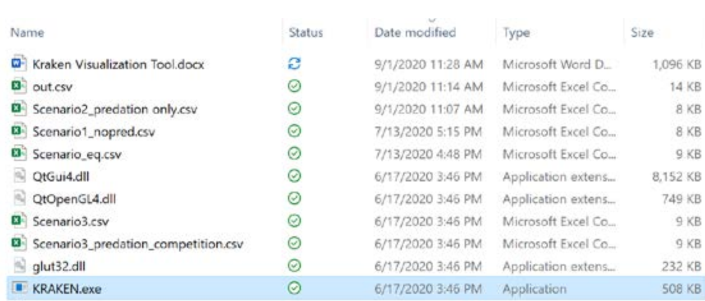
The initial conditions and interaction terms between stocks are intended to be plausible given what we know of the ecosystem, but should not be considered to describe specific, real world results where interactions, particularly competition is difficult to quantify, vary temporally and spatially, and are uncertain. The initial conditions and biological variables were based on past estimates of total biomass and fish growth. Predation rates were loosely based on food habits data, and competition based on life history traits and spatial overlap. Catchability by species (how much catch is generated by a unit of effort at various biomass levels) was set to be consistent with approximated survey biomass and commercial catch. Thus, the KVT should only be used to illustrate the interconnectedness of the real world ecosystem and explore possible scenarios. To be used in any other context, a more rigorously selected set of parameters will be required.

How to install and run the KVT on your computer

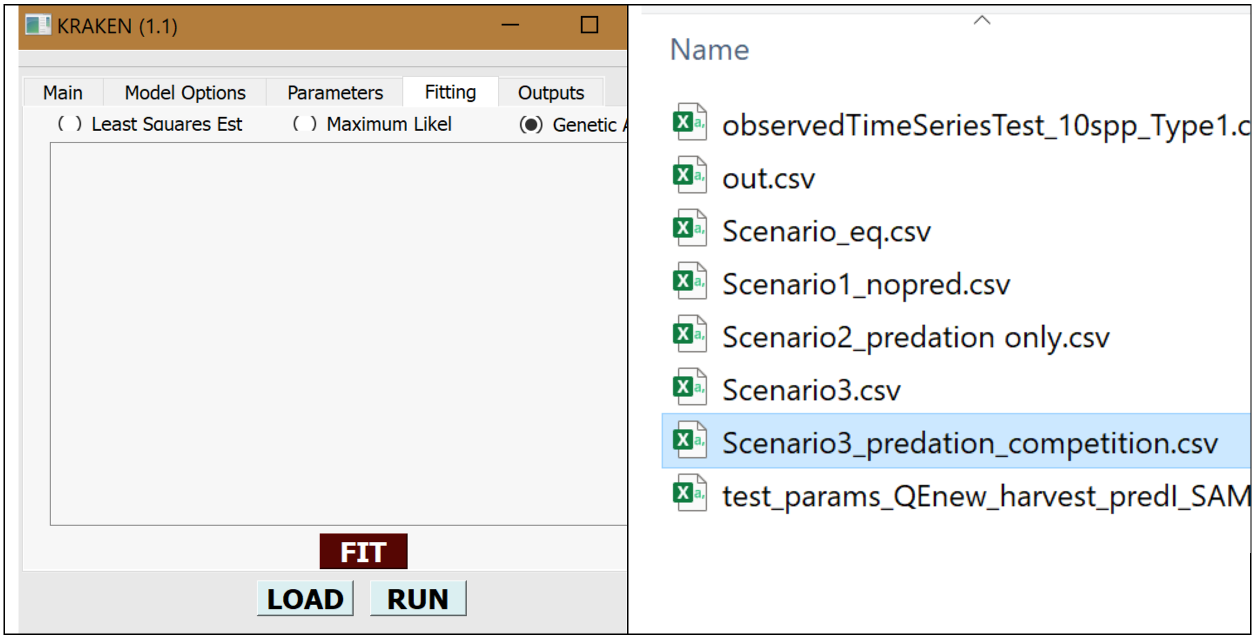
The KVT runs as an executable program (kraken.exe) on Windows computers. It might run on some Apple computers using a Windows emulator. There is no mobile phone/tablet app.

To install the program on your computer, download this Zip file and copy the files in it to an empty folder (it can have any name that you choose) on your computer.

To run the program, simply double click the KRAKEN.exe file.



Then select **LOAD**, choose the Scenario that you want to use (you need to make this selection twice, then select **RUN** to simulate the stocks and adjust effort levels to observe effects on the stocks and stock complexes.



The user can **adjust effort multipliers** for one to four stock complexes to examine what affect it has on stocks in that stock complex as well as other stocks in the model. **Four sliders** are provided to allow the user to change the relative amount of fishing effort (2x represents a doubling, 0.5x represents a halving relative to the base case of effort set equal to 1), which may be changed one at a time or in tandem.

Although fish in one stock complex may be caught by effort directed at another stock complex, the model does not account for incidental catch (either landings or bycatch). By changing the scenarios and adjusting the effort sliders, the user can see the indirect, secondary effects caused by predation or predation and food competition of effort changes on one stock complex on biomass of the other 10 stocks, including ones in the same stock complex.

There are **three scenarios** that the user may start with to demonstrate the concept.

1. Scenario 1 – No predator-prey or competition interactions (similar to single species models)
2. Scenario 2 – Predation only, no competition interactions
3. Scenario 3 – Predation and competition interactions.

What does the KVT show?

The KVT instantaneously shows the effect of changing effort pressure on one or more stocks over a 30-year time span, with or without biological interactions caused by predation and/or competition for food (Scenarios 1, 2, or 3). Results to help the user visualize and understand the primary and secondary effects of changing fishing effort caused by predation and/or competition for food include dynamic arcs to show how a stock behaves when the biomass of a predator stock changes and **three types of time series plots**.

The **dynamic arcs plots** (see Figure 1) consist of three components to interpret the effects of changes in biomass of a predator or competitor on another stock. The color of the arc represents the type of interaction: blue for predation, orange for competition. Arrows represent the directionality of the interaction, of predator on prey or of a competitor on its competition, which may be toggled on and off in the output for clarity. The width of the arcs represent the relative strength of the effect, wider arcs representing more predation or competition. Unfortunately, it would be very complex to show the size of the effect for 30 annual time periods in this output, so the authors of the tool chose to display the effect in the 30^{th} year. In addition to the directionality of effects of one stock on another, plus signs (+) indicate when declining biomass of a predator (or competitor) is beneficial for the other stock. It also displays a negative sign when increases in biomass of a predator (or competitor) is detrimental to the other stock.

The static or dynamic arcs showing stock interactions are displayed on the left and right sides of a static time series view of projected stock biomass (see Figure 1). There is no meaning between the left and right sides, except that on the left the effects are of a predator or competitor on a stock higher on the list and vice versa. The user may also make a selection to display dynamic arcs, which are animated to show the direction of the predation or competition. Relative trends in biomass are shown as a line with either a blended view or a reference line relative to status quo (i.e. all effort levels set to 1). Absolute levels of biomass relative to other stocks in the output is depicted by the size of the circles plotted every five years.

The user may also show **uncertainty plots** that show one of three types of graphs to depict the range of simulation outputs. The three types of output show the same data in different ways: multiline graphs, uncertainty bar (i.e. "box plots") graphs, or uncertainty bands (see Figure 2). To get this type of output, the user must select the "Run Simulations" button on the top left

A third type of plot shows trends in **stock biomass grouped into four panels by stock complex** (see Figure 3). In this display, the user can use the effort pressure sliders to see how the biomass projections change when one or more of the effort pressures are raised or lowered.

Figure 1. Plot of biomass trends and static view of predation and competition for a simulation with increased fishing effort targeting elasmobranchs. A colored blend shows a direction of change relative to status quo (in this case, fishing effort set to equal 1 for all stock complexes).

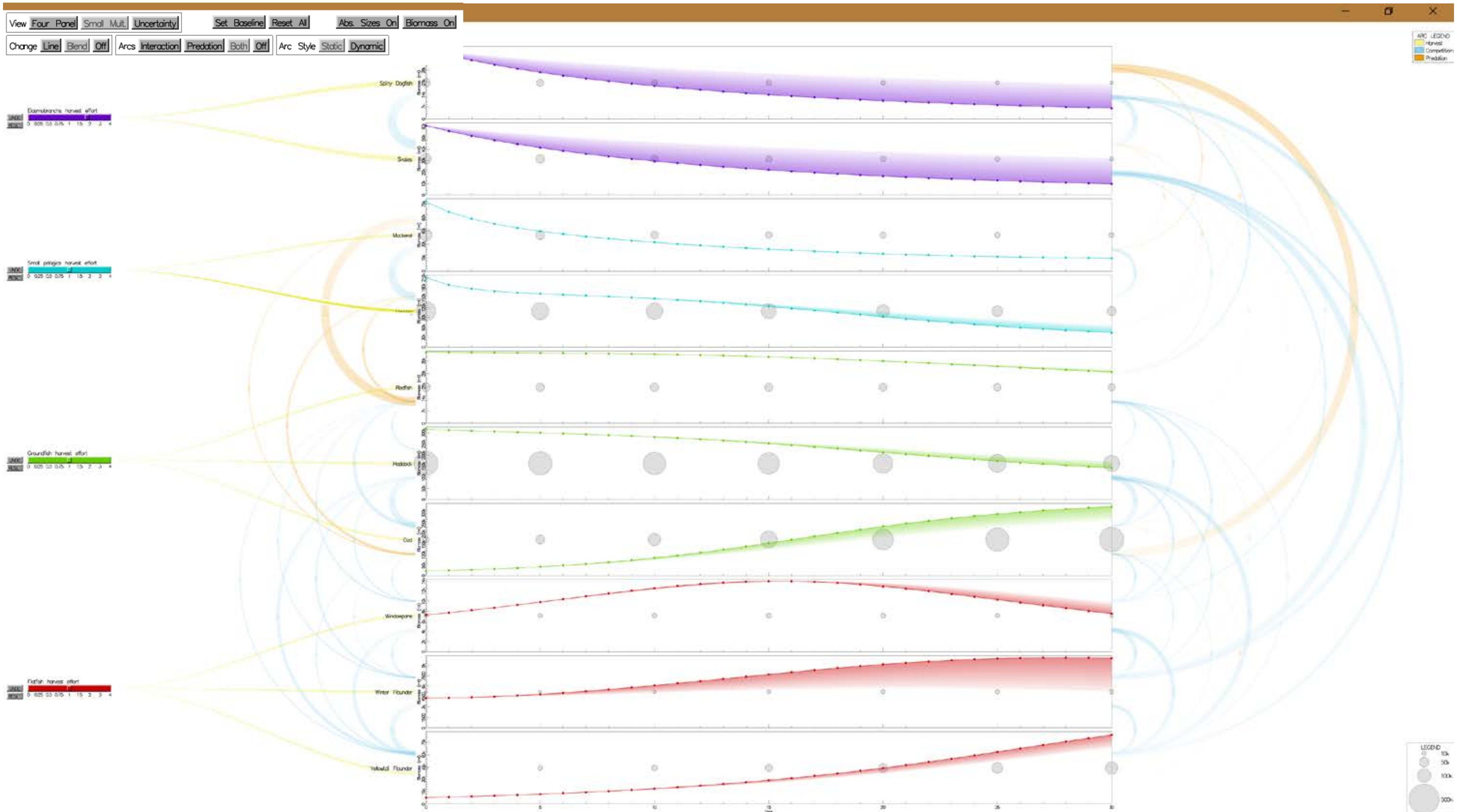


Figure 2. Trends in biomass by stock with uncertainty bands.

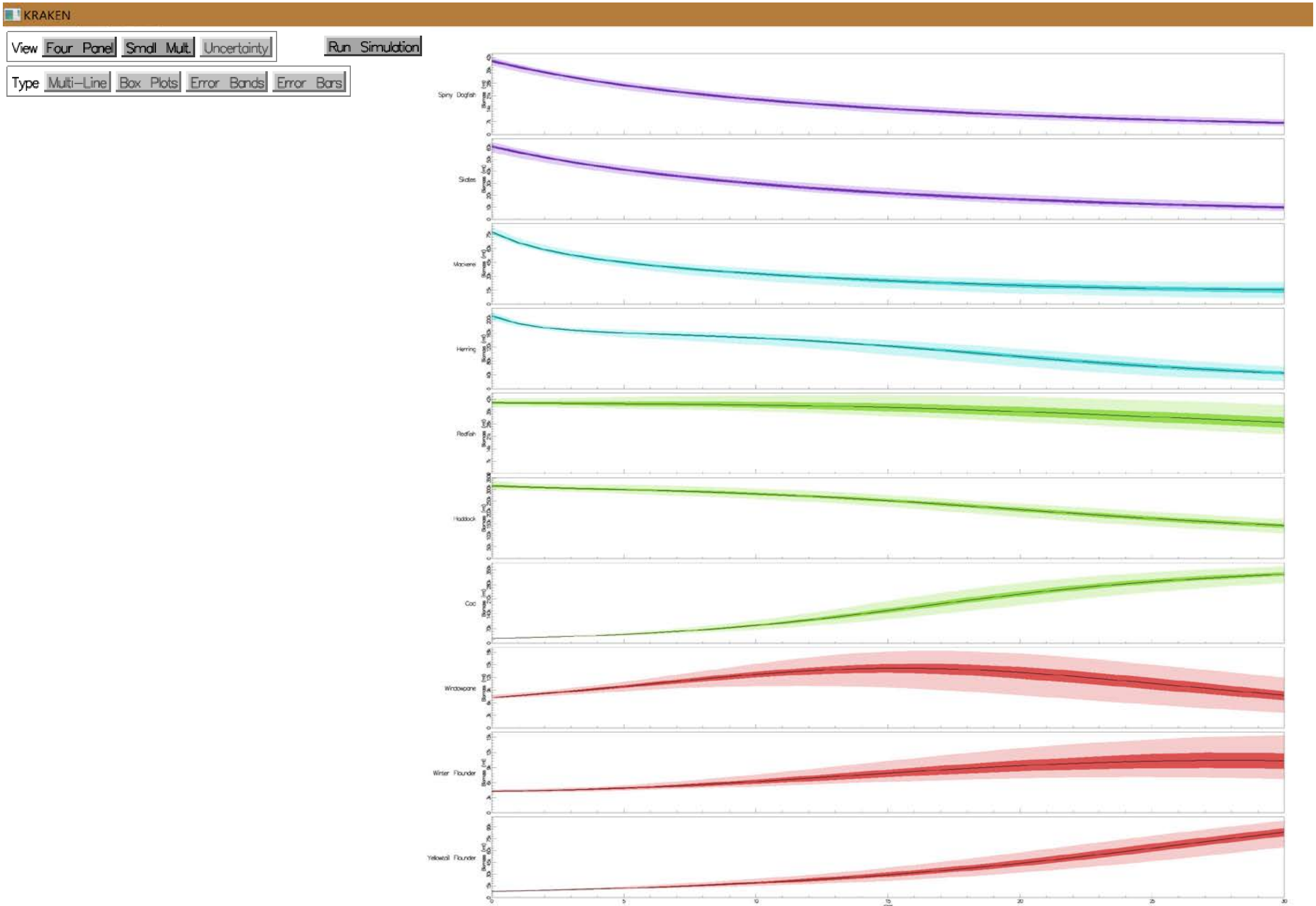
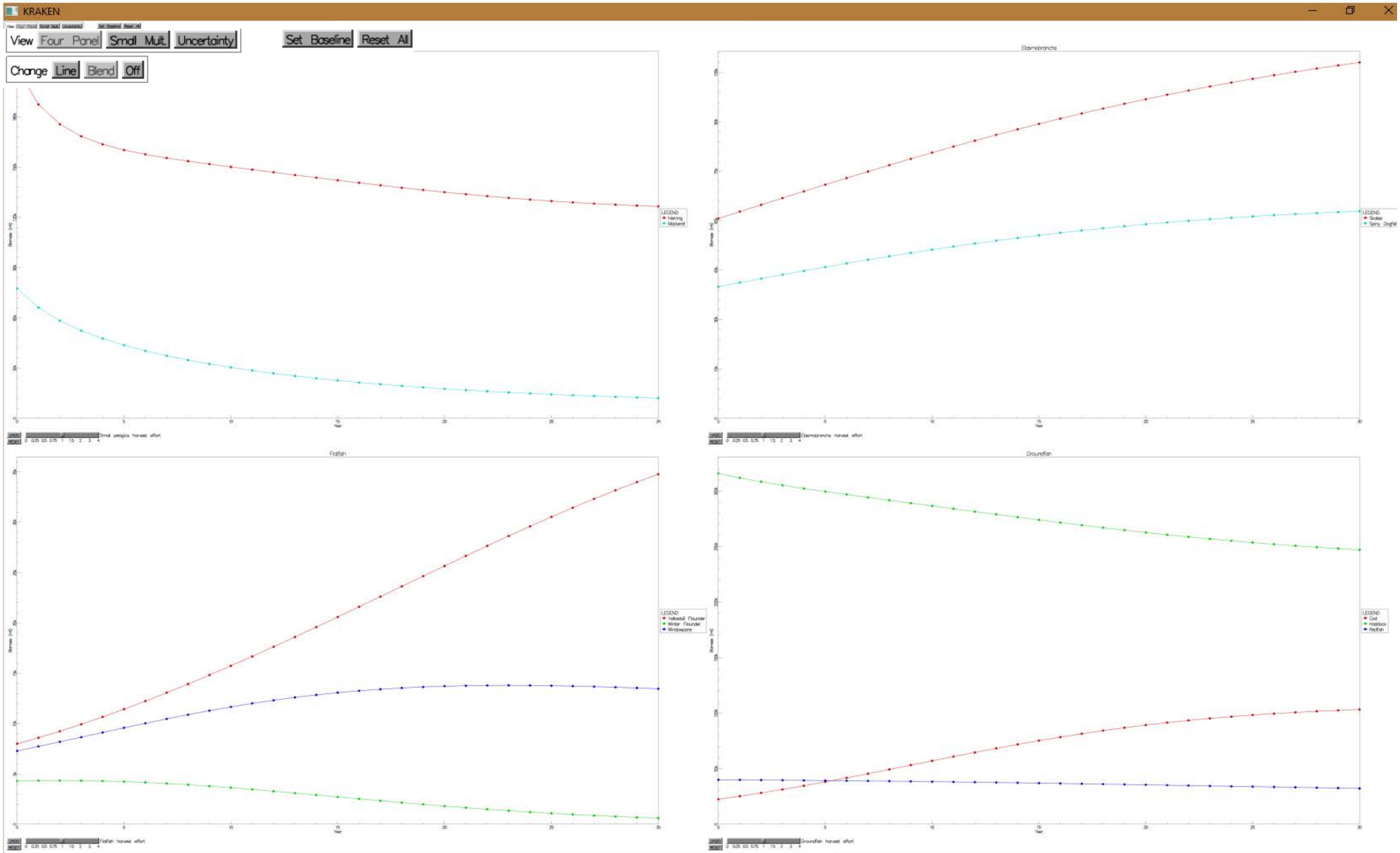


Figure 3. Four panel plot of trends in biomass by stock, grouped into four stock complexes. The user may adjust the effort level applied to a stock complex within this alternative display of model results.



What concepts can be explored?

It is worth discussing ways that the user can think about how effort is applied to stock complexes and how it translates into changes in biomass over time, with or without predation and/or competition.

In a simple case where a secondary effect is caused by predation (Scenario 2), increased fishing effort for groundfish directly cause a decline in cod, haddock, and redfish, species that are sensitive to high fishing effort. This causes an indirect effect on herring and mackerel biomass, which increases without changing small pelagic fishing effort because there are fewer of their predators, but there is no effect on spiny dogfish, skates, and flatfish.

If competition is applied (Scenario 3) and groundfish effort is again raised, cod, haddock, and redfish biomass decrease AND windowpane and yellowtail flounders biomass increase. But why do windowpane and yellowtail flounders biomass increase in this case? Indirectly, it causes lower flatfish biomass because cod compete with windowpane flounder and haddock compete with yellowtail flounder for food, and therefore as cod biomass decreases, windowpane flounder biomass increases due to less competition with cod. As haddock biomass decreases, yellowtail flounder biomass increases due to less competition with haddock. This indirect effect on windowpane and yellowtail flounders can be seen by comparing the same effort levels using Scenario 2 (predation only) and Scenario 3 (predation and competition). Now what happens when you increase fishing effort on BOTH groundfish AND flatfish? What happens when you decrease fishing effort on small pelagics, i.e. forage stocks?

The KVT simulation model is based on a multispecies production (biomass and catch weight) model developed by NOAA Fisheries scientists (Gamble and Link, 2009). Interactions are modelled as a set of logistic equations with two interaction matrices to represent predation or competition of stock 1 on stock 2, and stock 1 on stock 3, and stock 2 on stock 3, etc. The model produces a simulation for 30 years in annual increments with constant effort for each stock complex, set by the user

This visualization and application of the MS-PROD model is described in more scientific detail in “Dynamic Change Arcs to Explore Model Forecasts” by C.St. Jean, C. Ware, and R. Gamble, published in Eurographics, Volume 35 (2016), Number 3. A scientific description of the MS-PROD model was published as “Analyzing the tradeoffs among ecological and fishing effects on an example fishing community: A multispecies (fisheries) production model” in Ecological Modelling, Volume 220 (2009), Number 19.