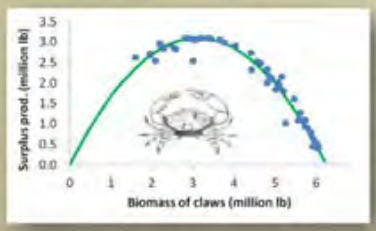
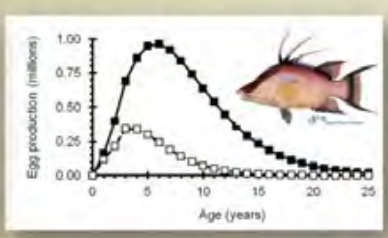
Types of Stock Assessments





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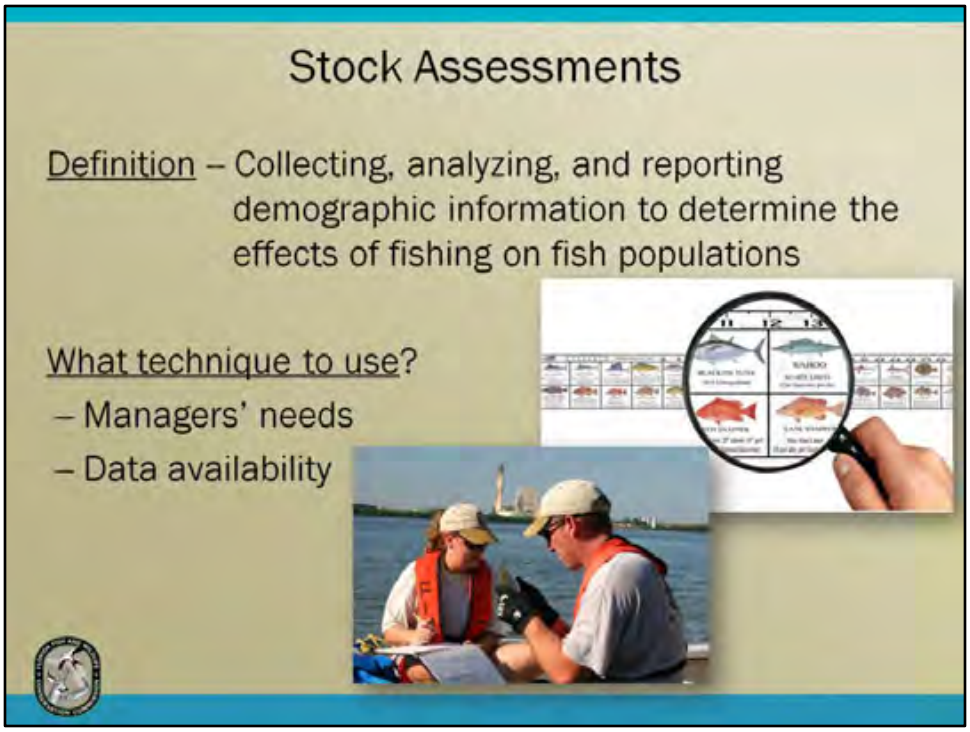
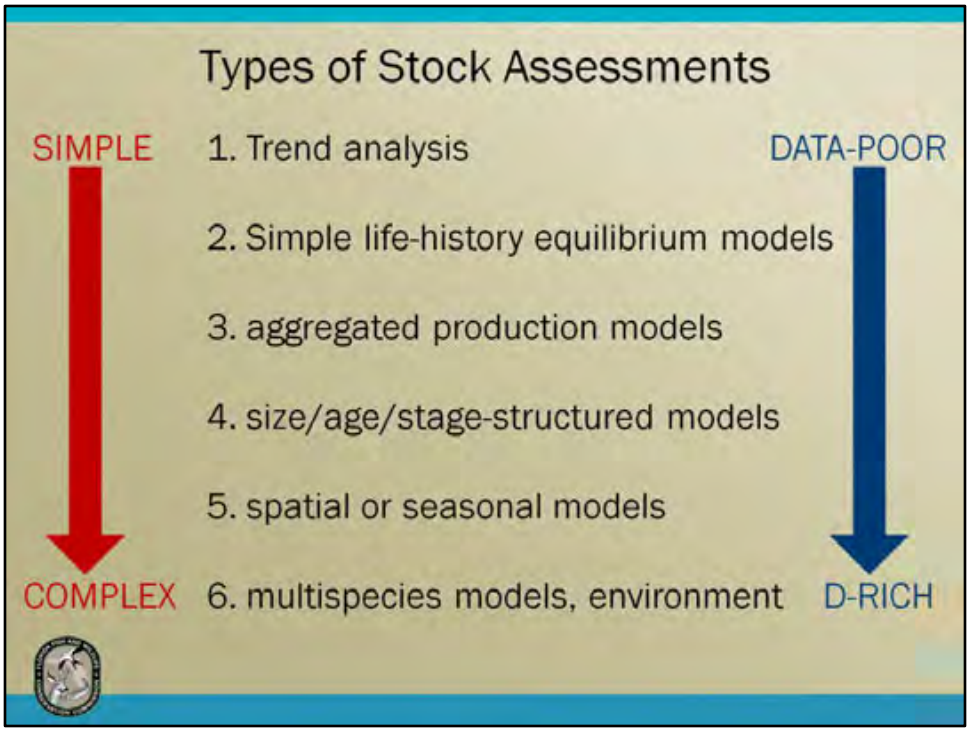
Florida Fish and Wildlife Conservation Commission
Fish and Wildlife Research Institute

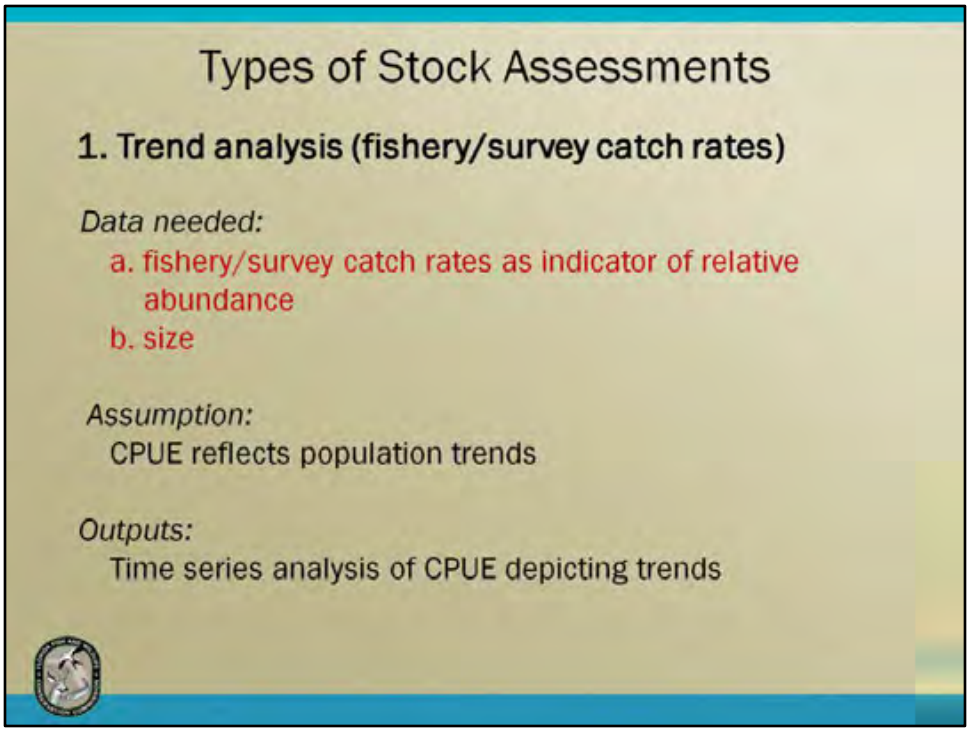
This presentation gives a brief overview and discussion of how fishery stock assessments range from simple to complex, including the data requirements and outputs



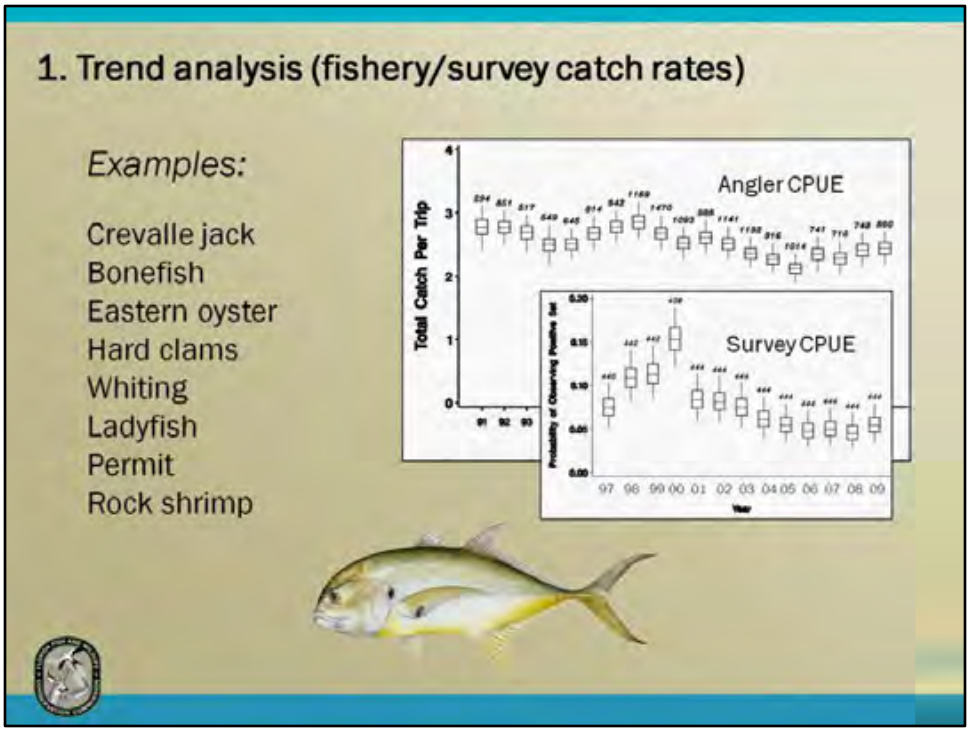
There are many types of stock assessments used in Florida. The reason for this diversity is that there are a variety of types of management actions the Commission chooses to use depending on the species in question and its fishery, e.g., size and bag limits, closed seasons, gear restrictions. Within this variety of assessments we are often constrained by the data available for the species or its fishery.



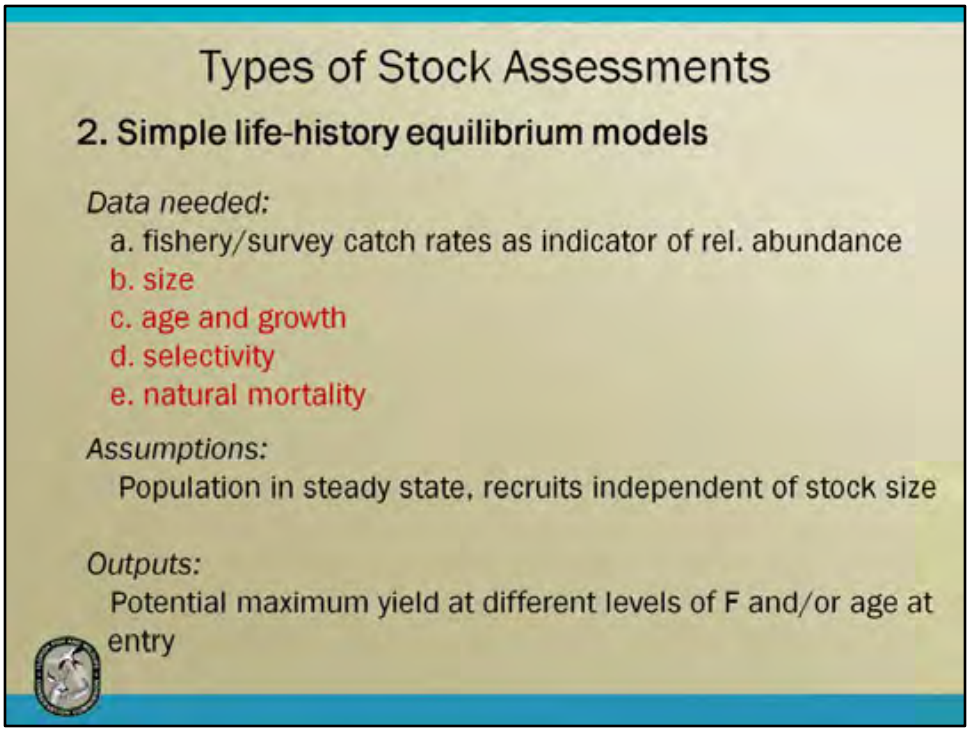
The choice of stock assessment models can range from very simple to quite complex. Naturally, simple stock assessments require less data whereas complex stock assessment require a lot of data. This presentation will briefly describe 6 types of assessments used in Florida that are found along this simple-to-complex continuum, indicate their data requirements, and the simplifying assumptions that must be met for a valid analysis.



The simplest assessment involves estimating the relative abundance level for a species and analyzing the trend or level against some benchmark set by managers. The requirements for this analysis is a representative catch rate, either from the fishery or from scientific surveys, made for the portion of the population that is under exploitation. This assessment analysis estimates a catch-per-unit-effort trend (CPUE). For this trend to impart information on the changes in abundance in the stock the CPUE must reflect the relative abundance of the species.



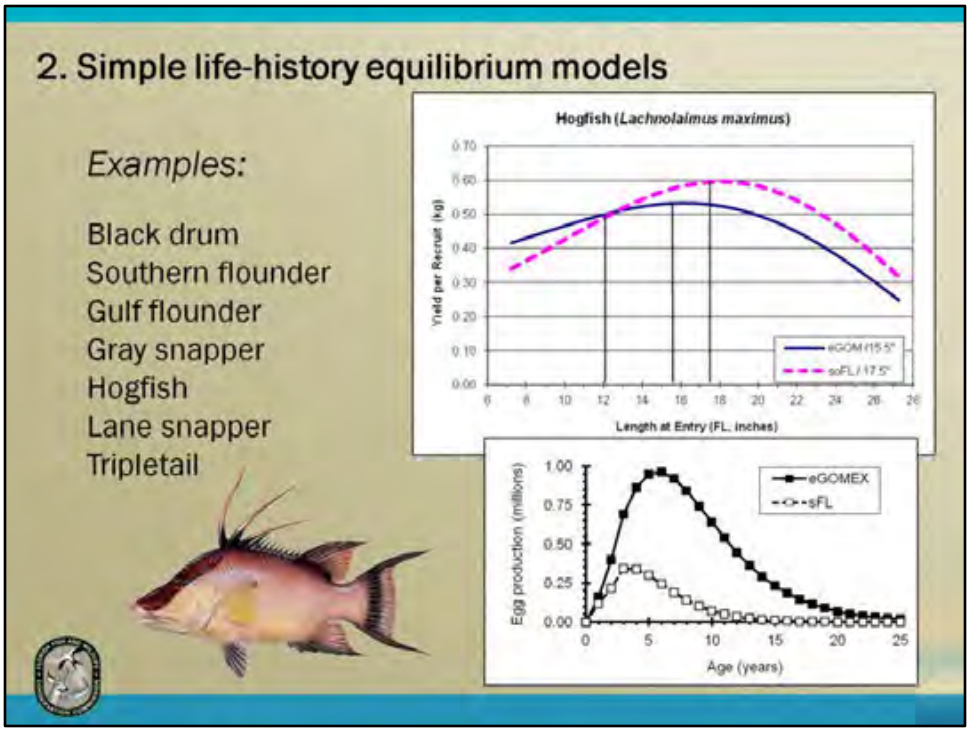
Many examples of trend analyses can be found in the annual Status and Trends Report published by the FWC's Fish and Wildlife Research Institute. The example on this slide shows the estimated total catch rate trend for anglers and the FWC-FWRI Fishery-Independent Survey catch rates for crevalle jack along Florida's gulf coast. You can see how the two mirror each other, adding confidence to the presumption that the CPUE is representative of stock abundance changes.



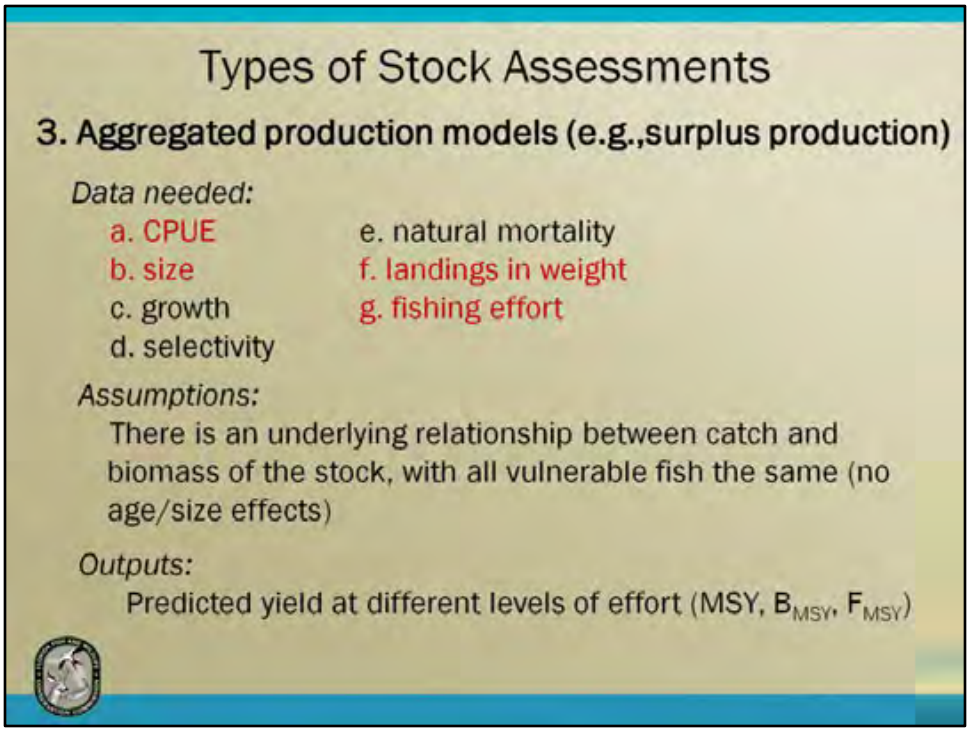
When there is insufficient data to measure changes in abundance over time from a survey, equilibrium models based solely on the life history characteristic of the species and the sizes of fish caught can be used to estimate how management can change the yield taken from the fishery. These are often called yield-per-recruit models because they assume a constant supply of new recruits to the population. The needed information is sizes of fish captured, age and growth information on the species, the selectivity of the fishery, i.e., what sizes are captured by fishermen, and a natural (non-fishing) mortality rate. These yield models can be extended to spawning biomass or egg-production per recruit is reproductive information is available.

All major assumptions for this analysis stem from the need for the population to be in steady state, i.e., recruitment and mortality are constant through time.

Though the assumptions are often not met, this analysis provides some guidance for changes in yield or spawning biomass (eggs) that can be expected with a change in fishing mortality or with size limit restrictions.



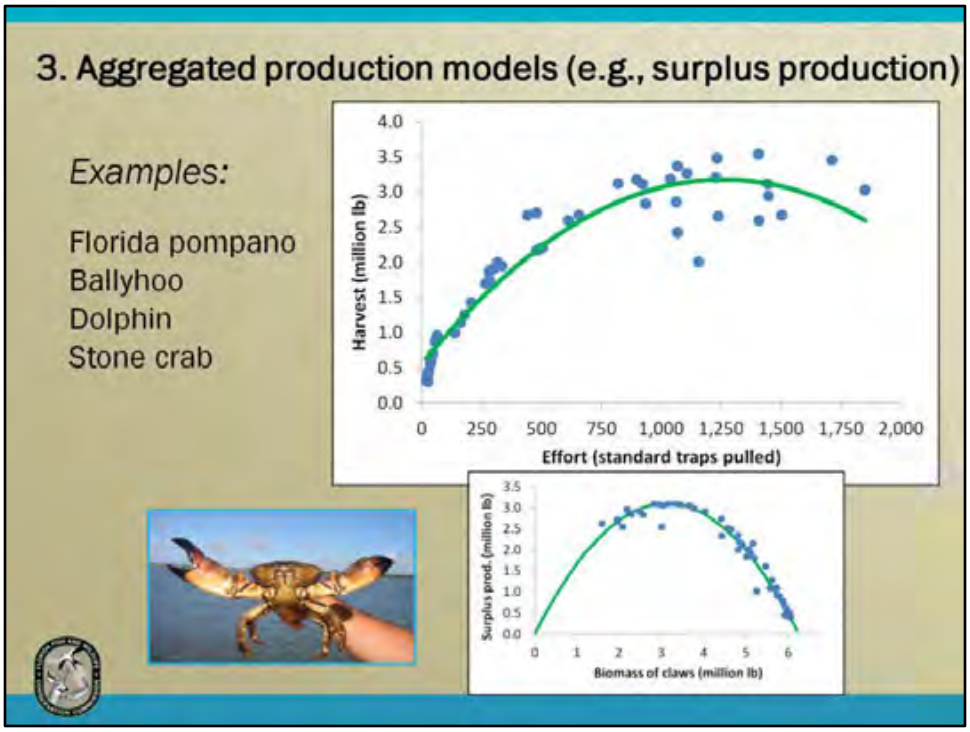
Early in the assessment of Florida's marine fishes, prior to scientific surveys or good fisheries catch rate information, these types of analyses were conducted for many of Florida's marine species, like black drum, southern flounder, gulf flounder and others. More recently, yield-per-recruit analysis was conducted for hogfish showing that under recent levels of exploitation, increases in the minimum size limit to almost 16 or 18 inches would increase yield-per-recruit. Using information on the regional reproduction and exploitation of hogfish, it was also found that the population egg production peaked at older ages in the eastern gulf of Mexico when compared to the Florida Keys.



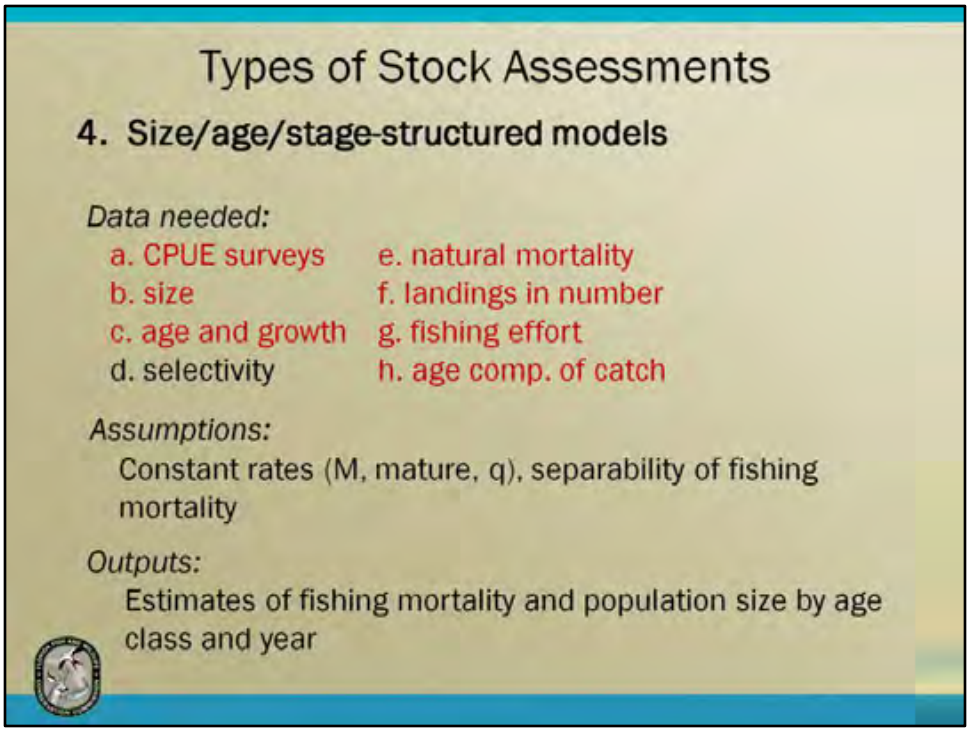
The next most complex assessments typically used in Florida are called production models. These attempt to estimate the capacity of the stock to grow (in biomass generally) in relation to how large the stock is and how close it is to a carrying capacity. The data required are moderate: a CPUE trend that represents the relative biomass of the stock, size information so the trend data are for the vulnerable stock only. Landings data, and fishing effort.

Given the underlying population dynamics model, this assessment assumes that the total biomass of the stock reacts quickly to changes in the amount of catch removed without regard to the sizes of fish making up the stock.

The outputs from this type of assessment are directly those needed for management under the benchmarks used for Federal fisheries and some state fisheries, the biomass at maximum sustainable yield, the value of maximum sustainable yield, and the effort or fishing mortality at maximum sustainable yield.

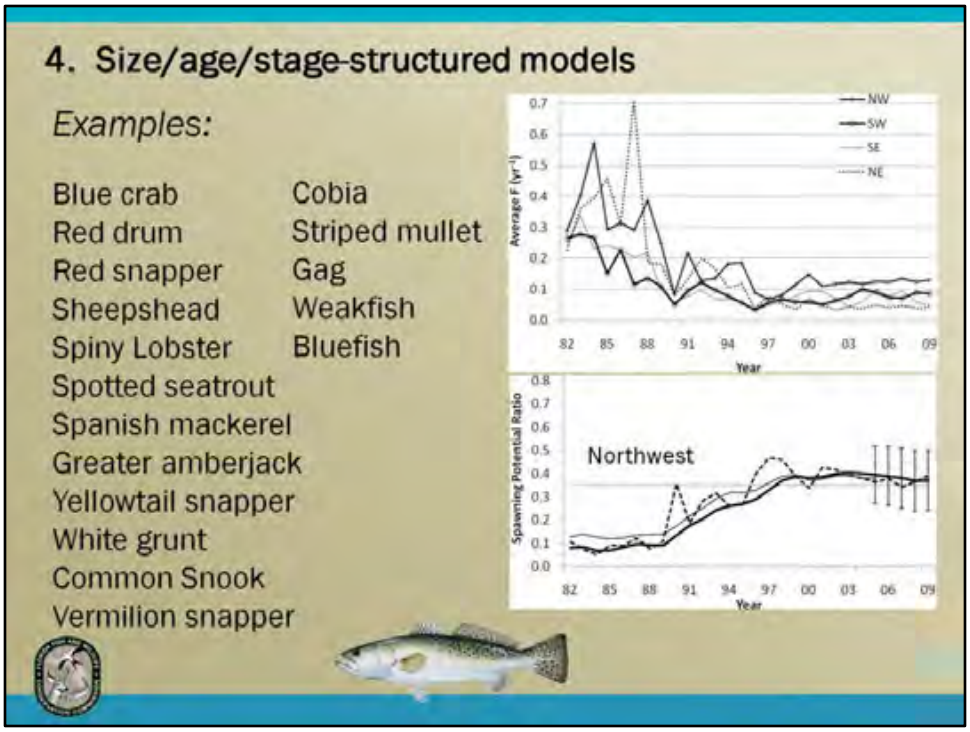


An example of the use of this model for a Florida fishery is the stone crab fishery, though it has been included in other state assessments like those for ballyhoo and Florida pompano. The graph shows that harvest of stone crab claws in Florida seem to peak at about 1,200,000 standard traps, without much of an increase past 600,000 traps. These could be thought of as the effort needed to harvest MSY. The biomass of stone crab claws at MSY and the harvest associated with MSY is seen on the inset graph showing a peak in harvest at about 3 million pounds.



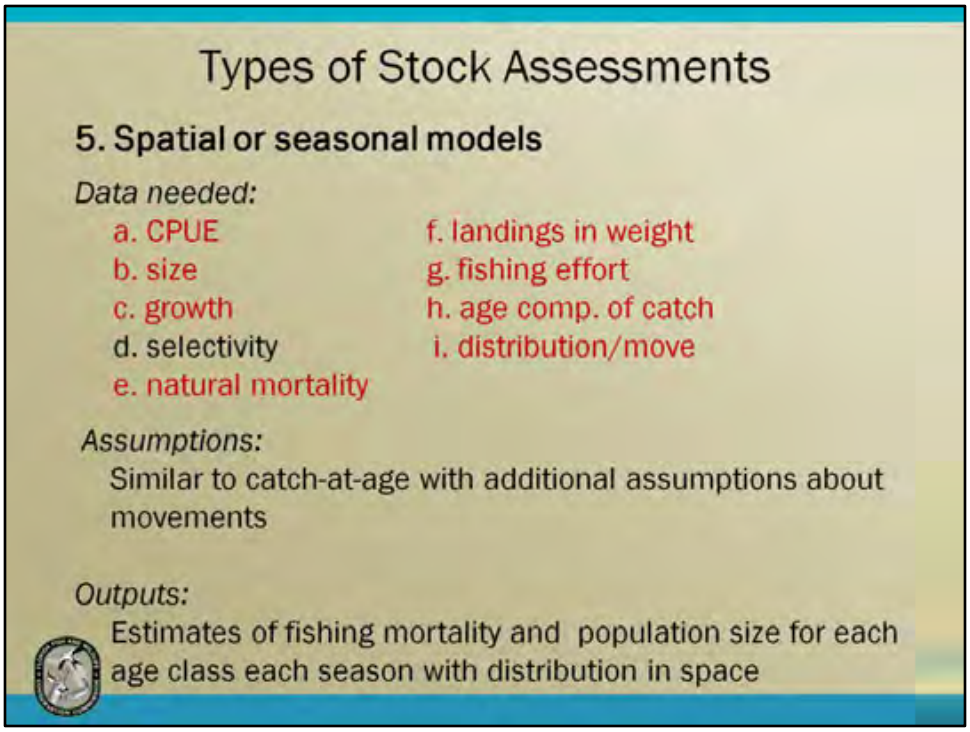
The next most complex assessment listed so far is the most commonly used for many of Florida's finfish assessments, the age-structured assessment. In addition to catch and survey information, these include information on the proportion of the catch and population within each age group each year. This is an important difference because these data provide for a more realistic representation of the stock than that of the production model. In other words this analysis can differentiate between stocks with lots of young immature fish and stocks with mostly old mature fish. A number of assumptions are generally made in the assessments we've used, including assumptions that some of the vital rates are constant over time, surveys are proportional to population abundance and fishing mortality can be estimated for each year and then apportioned across ages.

Outputs from these models are age-specific rates of fishing mortality and abundance. With this level of detail, the potential effect of many more management options can be explored directly than can for production models.



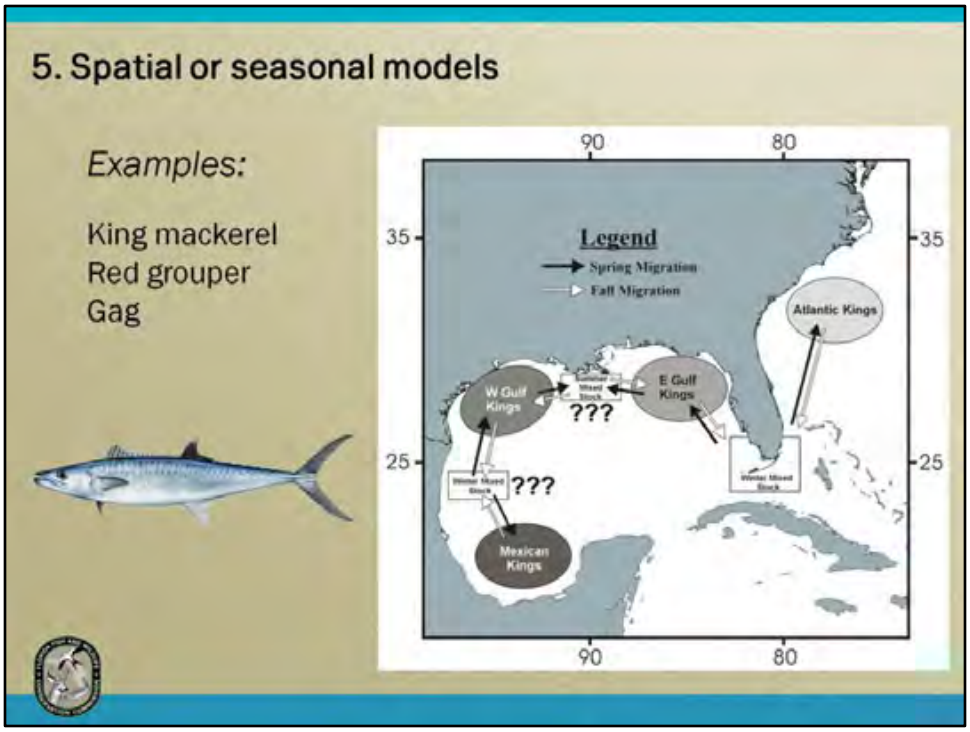
Spotted seatrout have enough age composition data and survey information to support the use of age-structured assessment models within the regional framework chosen by the Commission. The graphs show the region-specific declines in average fishing mortality that occurred as management became more restrictive during the 1980's, with average fishing mortality low since about 1990. With the age composition data, the analysis also picks up the slow rebuilding of the stocks reproductive capacity during the time when fishing mortality remained low until coming into balance with these lower rates as seen for the Northwest region.

Other state species commonly assessed using this type of assessment include blue crab, red drum, sheepshead, striped mullet, and snook. Many federally-managed species are also assessed using these techniques.

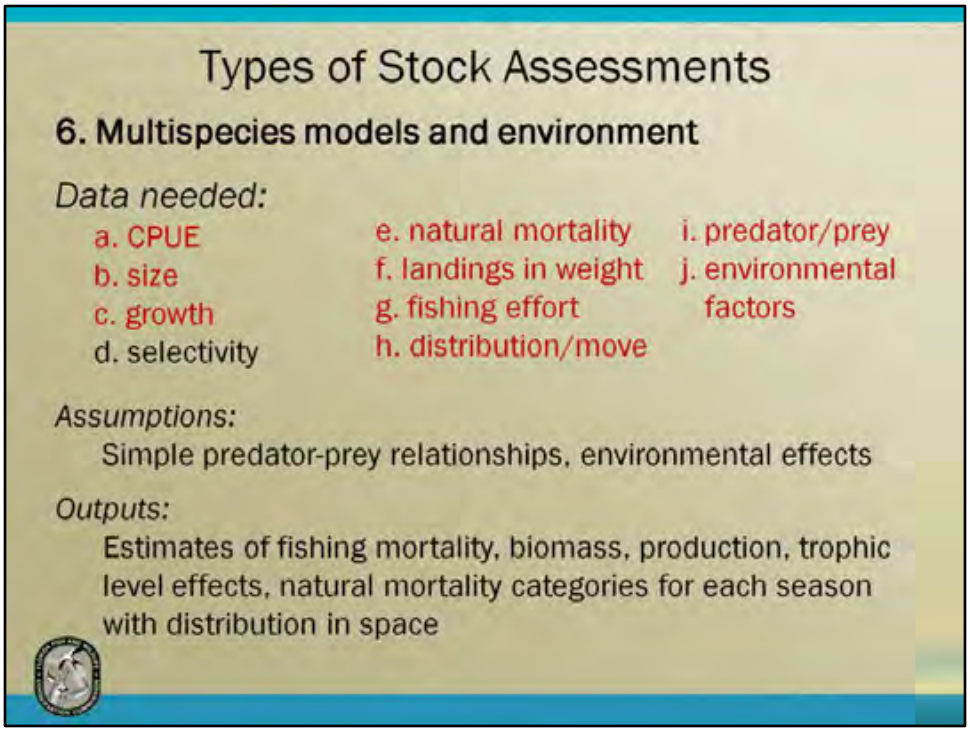


In routine stock assessments described above the movement of fish within the stock area is not considered nor is their interaction with other species and the environment. Spatially-explicit assessments and multispecies assessments attempt to include these factors but require a lot of detailed information . This type of information is rarely available and never complete.

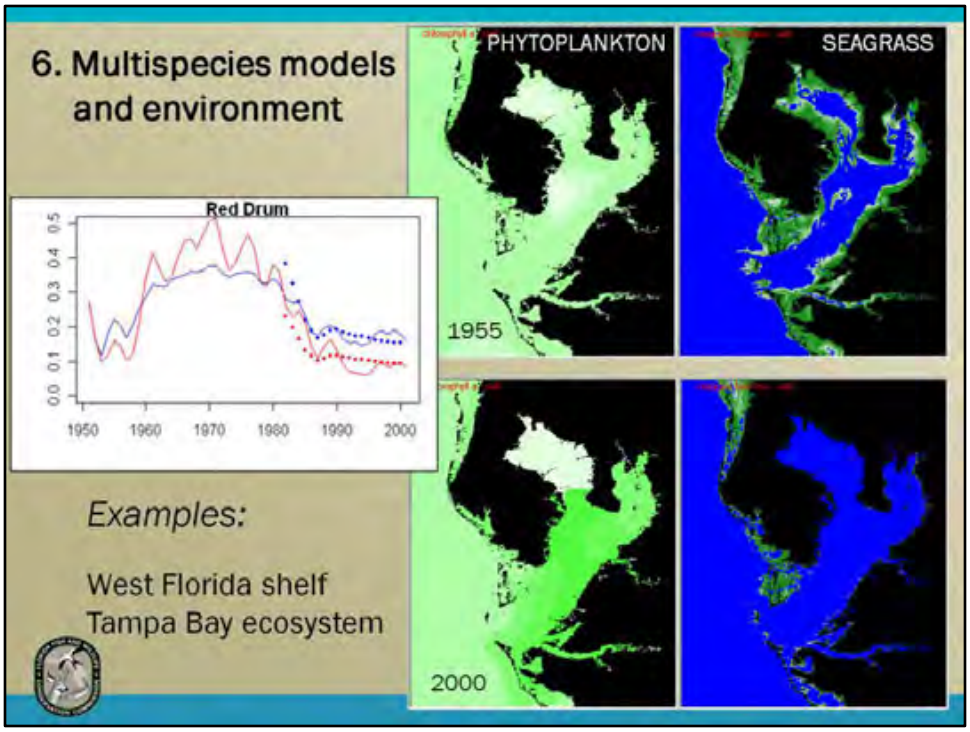
Spatial models are much like age-structured assessments but additional consideration is given to the changing distribution of the stock throughout the year



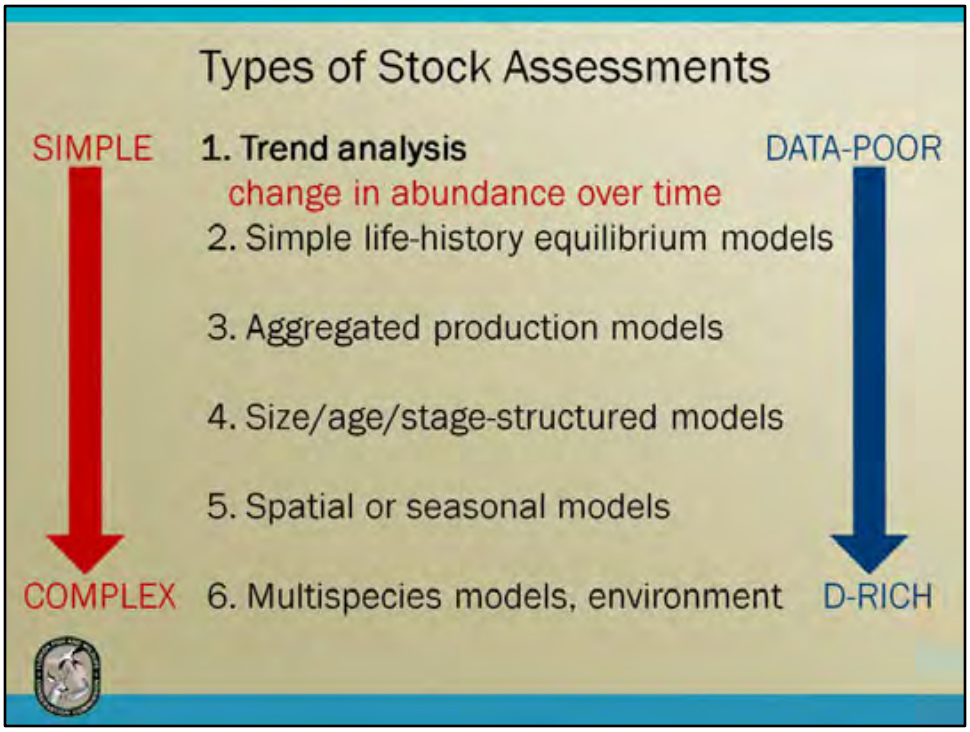
A good example is the assessment of king mackerel. During the last assessment cycle, a spatial model was attempted but complications and data requirements eventually forced the assessment team to abandon this approach and use a more traditional age-structured model.



The multi-species assessment appeals intuitively because it explicitly includes other predators and prey for the species being assessed. However, this requires an enormous amount of information collected using survey data, food habits studies, and environmental monitoring efforts. When successful, it can provide category-specific estimates of fishing mortality, biomass, and natural mortality changes over time; in general it gives a measure of the productivity of different parts of the ecosystem.

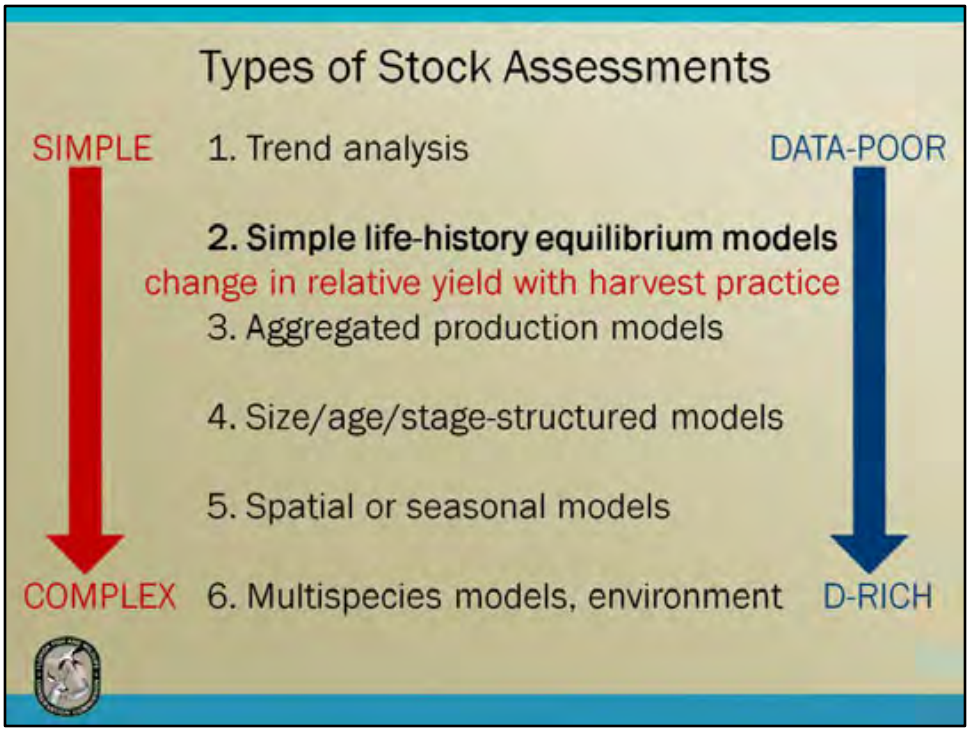


FWC's Fish and Wildlife Research Institute has a complex assessment model of Tampa Bay that considers many factors including nutrients, phytoplankton and seagrass cover. It provides estimates of the expected phytoplankton production over time, how seagrass cover changes over time, and the general productivity of the estuarine portion of many fish and shellfish stocks including red drum.

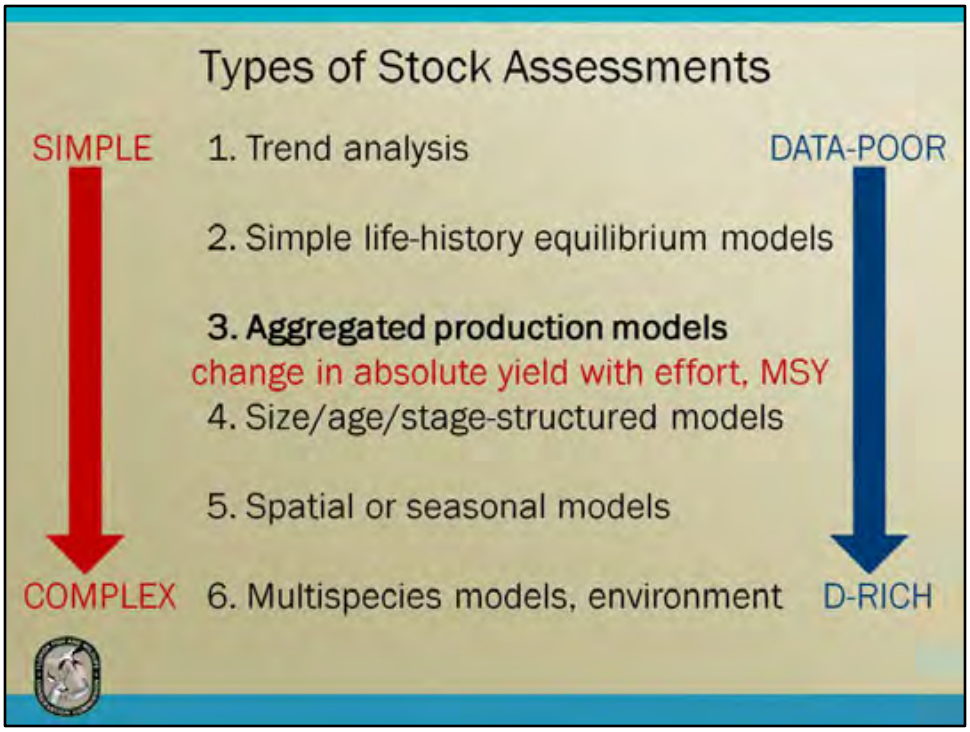


So as a quick review of what we gain from increasing the complexity of assessments we use:

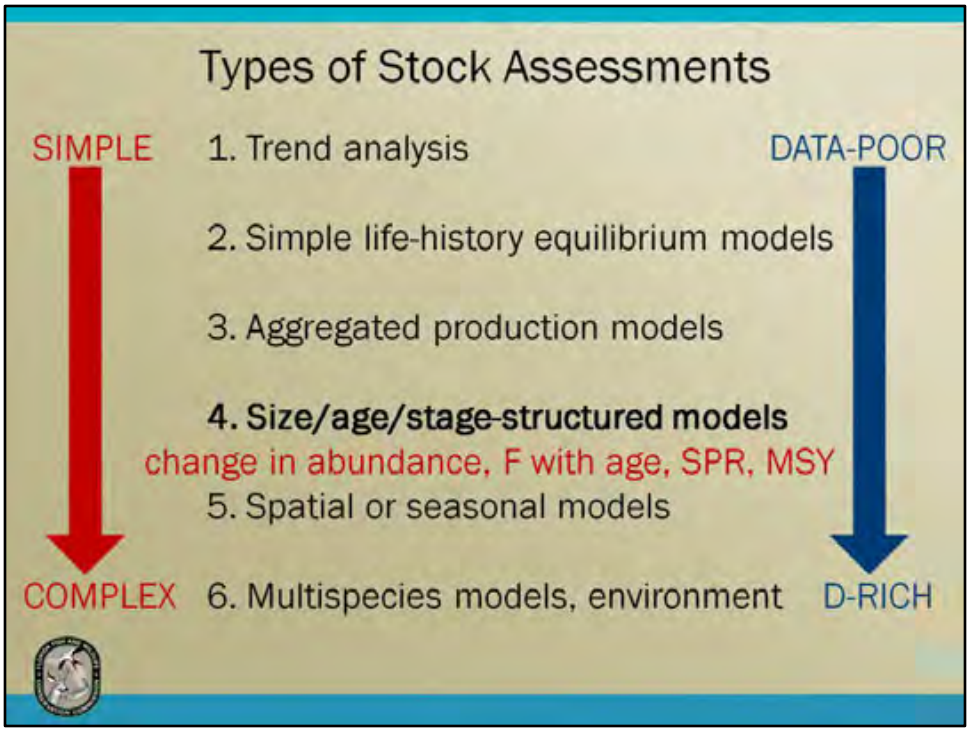
A trend analysis can give us a change in abundance over time and if there is a management trigger level it can be used as a call to action for managers.



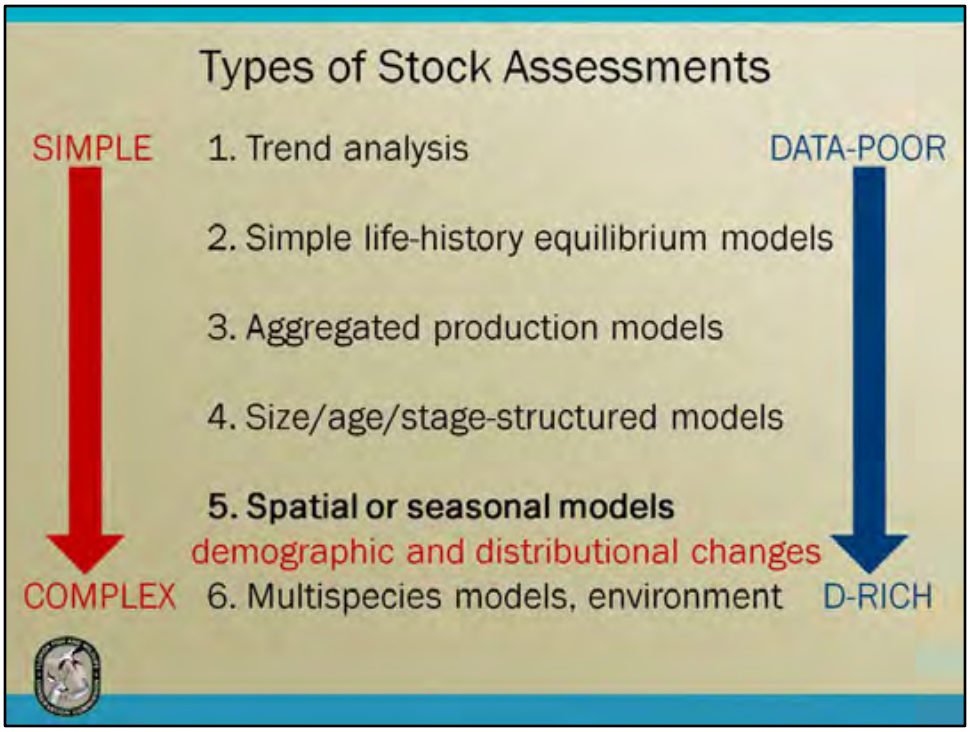
Simple yield-per-recruit or spawning-stock-biomass-per-recruit models can give us guidance on how relative yield or spawning capacity might change with changes in fishing mortality or size limits.



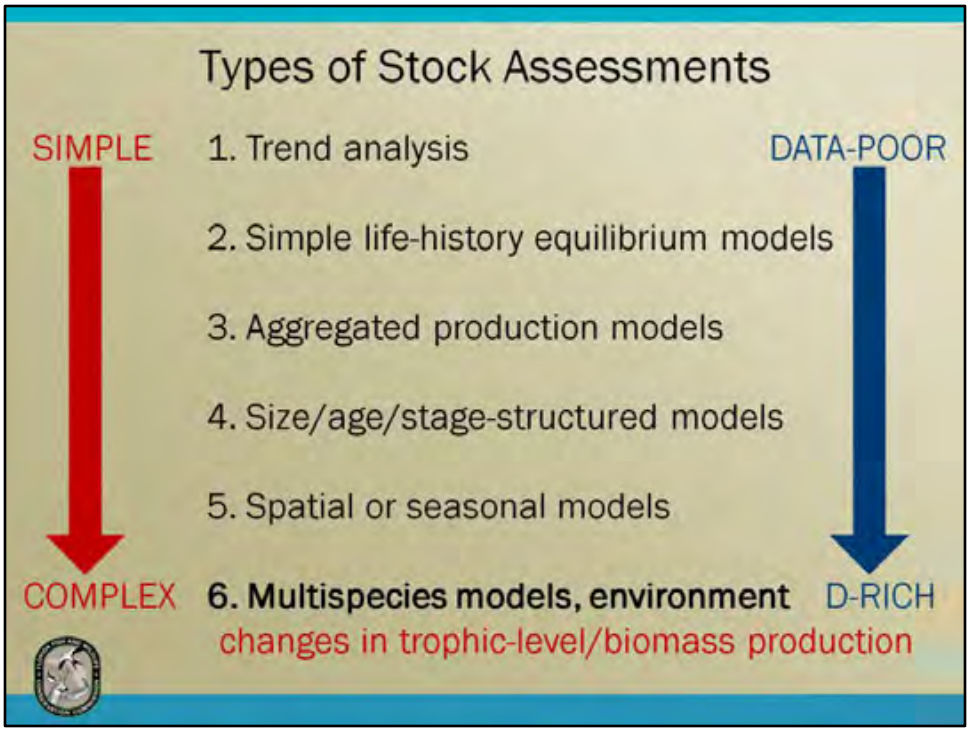
Production models can be used to determine whether the stock is being fished at maximum sustainable yield and what changes in fishing would be necessary to achieve MSY.



Age-structured assessment models provide us with a large amount of age-specific information good for determining the impacts from various management options such as size limits, bag limits, season closures, etc.



And spatial models do much the same but with explicit modeling of the movement of migratory animals through time so any time-specific management option or scenario can be fine-tuned.



And finally multi-species models provide information about the productivity of the system under various levels of fishing mortality and exploitation patterns. These would theoretically allow managers to choose from different ecological states, while seeing clearly what the trade-offs would be to achieve particular management goals.