Stock assessment

—Assessment types—

Meaning: The use of data from fishery dependent and fishery independent sources to assess fish populations to inform management on the regulation of fisheries.

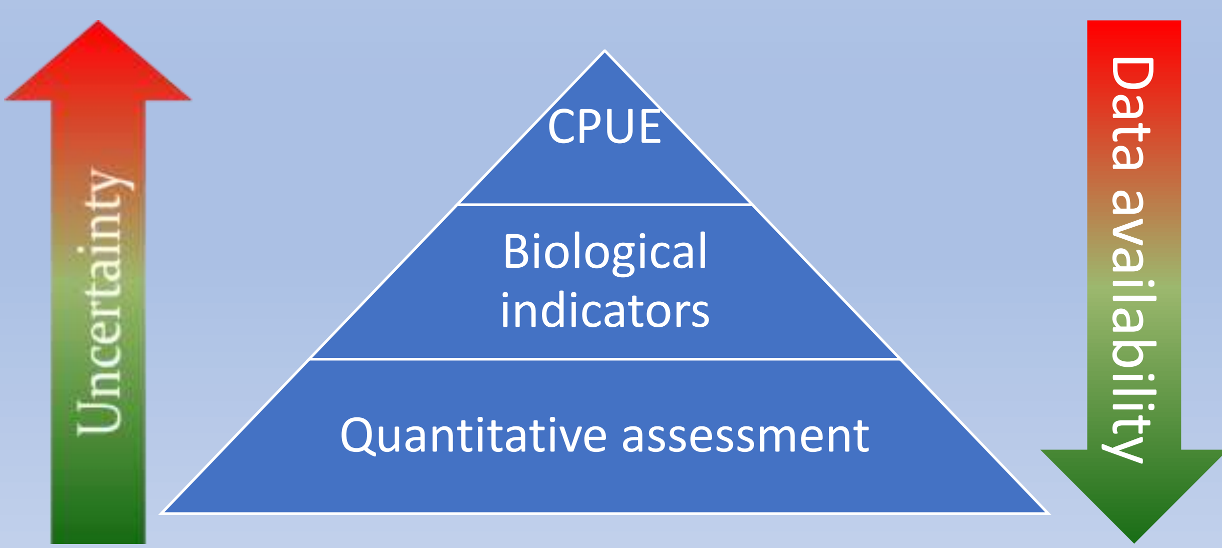
Stock assessments are used to describe the current state of the stock relative to management objective for the fishery, and to inform management of the stock in line with those objectives.

There are many types of stock assessments, and the type used often depends on the level of data available.

Data poor stocks – stocks for which a standard, quantitative assessment that estimates changes in population biomass through time **cannot** be conducted.

Data rich stocks – the stocks for which a standard, quantitative assessment that estimates changes in population biomass through time **can** be conducted.

The more data available, the more sophisticated stock assessment that can be undertaken, and the less uncertainty in their results.



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Stock assessment

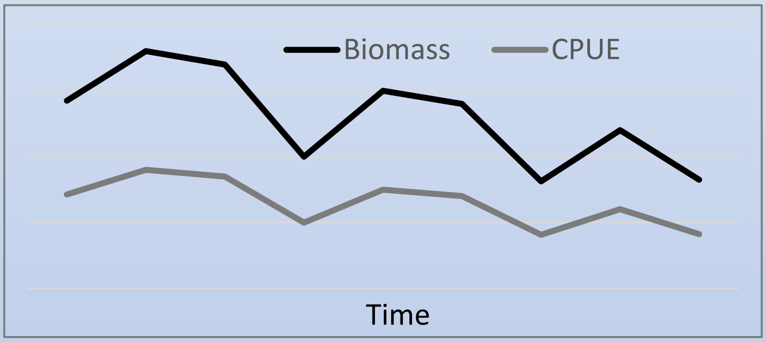
— Catch per unit effort —

Meaning: The number or weight of fish caught by a unit of fishing effort.

Symbol: ***CPUE***

One of the simplest forms of stock assessment uses just **Catch Per Unit Effort (CPUE)**. The minimum data requirements are catch weigh or number reported per fishing operation, or fishing day. This is improved if more informative measures of effort are recorded (e.g. number of hooks used or number of hours fished).

The use of ***CPUE*** as an indicator of biomass relies on the assumption that CPUE is proportional to stock size. But this assumption is often not met.



The catchability can change over time for reasons other than the biomass of fish.

- Availability
- Targeting
- The environment
- Moon phase
- Season
- Time of day
- Hyperstability
- Depth
- Fishing gear
- Fisher skill

Most of these can be dealt with by **standardising CPUE**.

Hyperstability is where CPUE initially declines more slowly than true abundance as a stock declines. This can be caused by the schooling behaviour of fish. Even as more fish are removed, the fish continue to school tightly, which makes them more vulnerable to fishing pressure.

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Stock assessment

— Standardised CPUE —

There are a lot of variables other than stock biomass that might effect **CPUE**. A new, more efficient boat might enter the fishery. The weather might be particularly bad in one year, restricting fishing effort to shallower depths that are less productive. A cyclone might have stopped the fleet fishing during what was normally the most productive month.

If these factors aren't taken into account, the stock assessment could make incorrect conclusions, resulting in bad advice provided to fisheries managers.

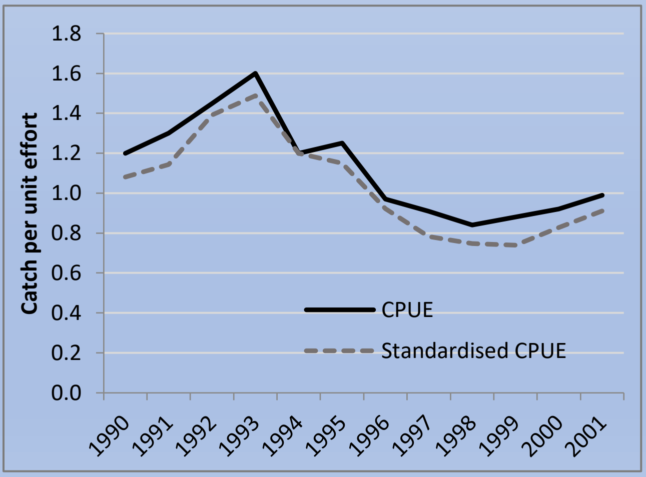
The statistical tool used to take those factors into account is **CPUE standardization**.

The first step is to work out what factors need to be included in the **CPUE standardization** model. This is usually done by a combination of talking to the fishers and exploratory data analyses.

A standardized CPUE model will often look something like this:

Year + Vessel + Month + Zone + DepthCategory + Zone:Month

This just shows what factors were included in the standardization. The last one, Zone:Month, is a combination of two factors. This is called an interaction. It means that the effect of Zone on CPUE changes seasonally (i.e. CPUE might be highest in January in one zone, but highest in June in another). Interactions can have more than 2 factors.



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Stock assessment

— Quantitative Stock Assessment—

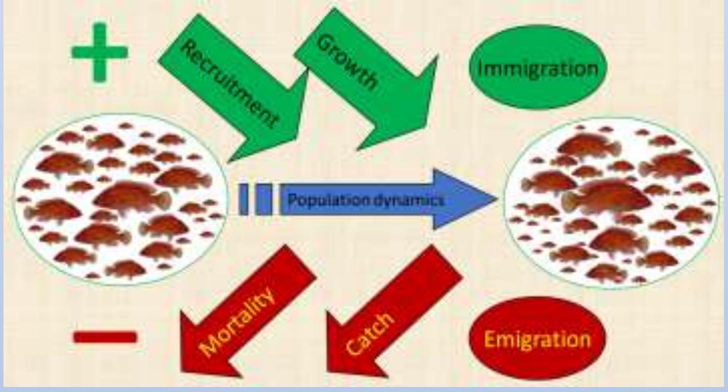
Meaning: Calculations based on available information to estimate sustainable yields and current and / or future stock status.

For **data rich** stocks, stock assessments are often done using **quantitative stock assessments**. Result from **quantitative stock assessments** provide fishery managers with comprehensive information with the least amount of uncertainty.

Stock assessments are only as good as the data that goes into them. A lot of time is spent at the start of the stock assessment process in making sure that the data is as accurate and up-to-date as possible.

Inputs to stock assessments include:

- Retained and discarded catches
- Length frequency data
- Growth
- Maturity
- Fecundity
- Recruitment
- Selectivity
- Retention
- Length-weight relationship
- Natural mortality



The **stock assessment model** combines all of this information using mathematical equations. The model does its best to calculate biomass for each year by seeing what combinations of the inputs makes the most sense in a biologically realistic way. Comparing how the model performs to collected data can evaluate how reliable the model is. It repeats the calculations thousands of time until it finds the model with the "**best fit**". This just means that tries to find the model that results in data predictions that are most similar to the actual input data. Graphs and numerical summaries of these comparisons are called diagnostics, and are used by the fisheries scientists to check that the model is behaving as they expected.

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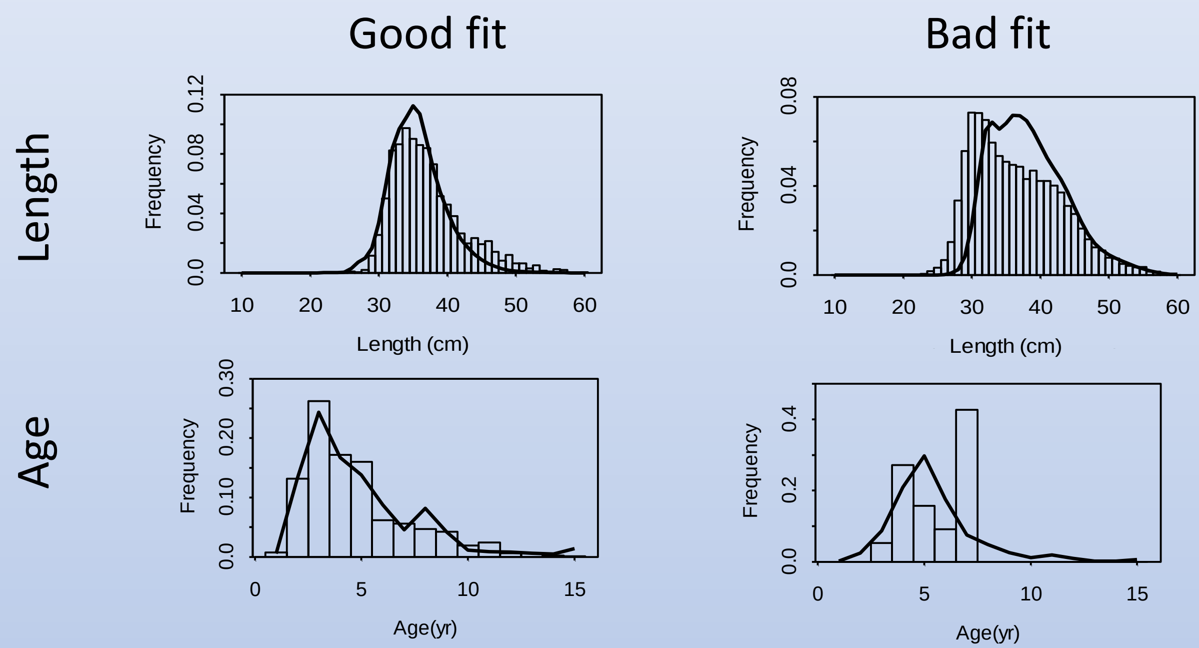
Stock assessment

— Diagnostics—

It is important that fisheries scientists have some way of checking that a stock assessment model makes sense. One way of doing that is by using **diagnostic** summaries to see how closely the model predicts the things we know — such as the data we used as inputs or otherwise known as observations.



The bars are the raw data, the lines are the modelled values

A poor **fit** to the data could be caused by either a model that is not accurately reflecting the stock's population dynamics, or that the data do not accurately reflecting the stocks population dynamics (e.g. that the length-frequency sample is from not enough catches, and so for example in the top right graph, small fish are over-represented). This can be dealt with by reviewing the input data to ensure it is correct, reducing the reliance of the stock assessment model on that particular data, or by excluding those data.

Another type of diagnostic is called a "**goodness of fit**", which describes how well the model fits the data — they summarise how well the predicted values match the observations in a single number. There are many types of "goodness of fit", and generally the lower the number the better the fit. It is important to note that a goodness of fit cannot be used in isolation to tell how good a model is, rather than compare the results of different runs of the same model.

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Stock assessment

— Sensitivity testing—

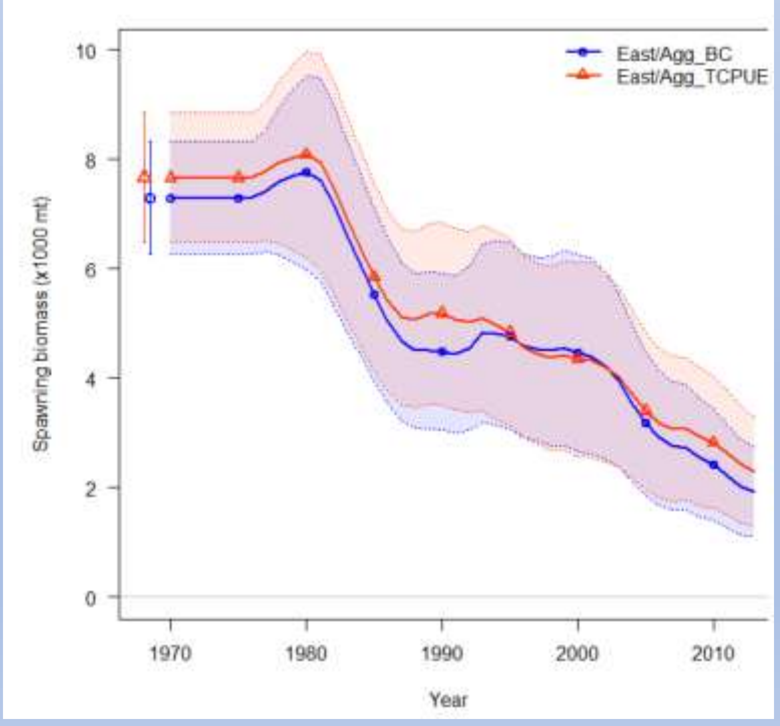
There are a whole lot of assumptions involved with quantitative stock assessments. What are the effects on assessment results if the assumptions are wrong?

The final, agreed stock assessment model is called the **base case**. The **base case** model has been reviewed, its diagnostics checked, and inputs changed so that there is agreement amongst the assessment group that based on the best available information, the **base case** model is the one that provides the most confidence.

To look at the implications of making a wrong assumption, or to see where improved data needs to be collected to reduce uncertainty, inputs are often changed, and the results compared to the **base case** results. This is called sensitivity testing, as it tests the sensitivity of the model to changes in inputs. For example, if the **base case** used ***M*** = 0.3, the model might be run again with ***M*** at 0.25 and again at 0.35. Other common sensitivity tests are for steepness, recruitment variability or the weight of importance placed on other inputs.

For example, this graph shows the effect on model estimates of spawning biomass of Pink Ling resulting from using two different measures of **CPUE**.

Sensitivity testing can point to data that need to be reviewed or improved through better or increased data collection.



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Stock assessment

— Understanding the outputs—

The most important information provided by stock assessments are the estimate of the current **stock biomass (*B*)** against its pre-fishing levels, and the forecasted stock biomass for different levels of future catch.

Stock biomass or **spawning stock biomass** are common **indicators** used in **harvest strategies** for **data rich** species. But that's not enough by itself, as to describe how healthy the stock is, we need to be able to compare that **stock biomass** against **reference points** that might include **virgin biomass (B_0)** which is the average biomass of a stock that has yet not been fished as calculated by the **stock assessment model,** the average biomass of a stock during the early years of the fishery, and a level of **stock biomass** that management aim to keep the fishery at such as the **target reference point** (B_{targ}).

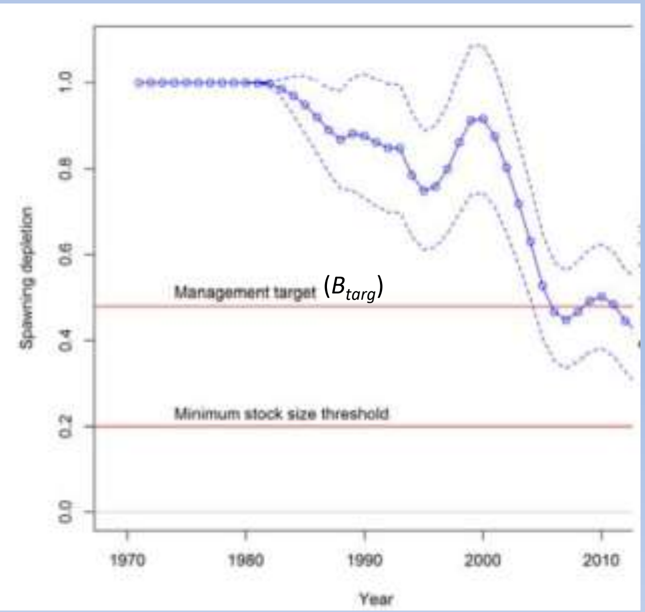
Stock assessments commonly report results showing B_0, B and B/B_0. The last figure, B/B_0 (also referred to as the level of **depletion**) is used to categorises the stock as either **overfished** or **not overfished**.

Another main output from stock assessments is a **recommended biological catch (RBC)**. The **RBC** is an estimate of the total **fishing mortality** (landings from all sectors plus discards) recommended to achieve B_{targ}. If the actual biological catch is greater than the **RBC**, the stock can be categorised as being **subject to overfishing**.

The **Total Allowable Catch (TAC)** for some Commonwealth fisheries is calculated from the **RBC** as follows:

TAC = **RBC** – **discards** – state catches

This graph shows the estimated depletion level for Pink Ling against the management target (B_{targ}).



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Stock assessment

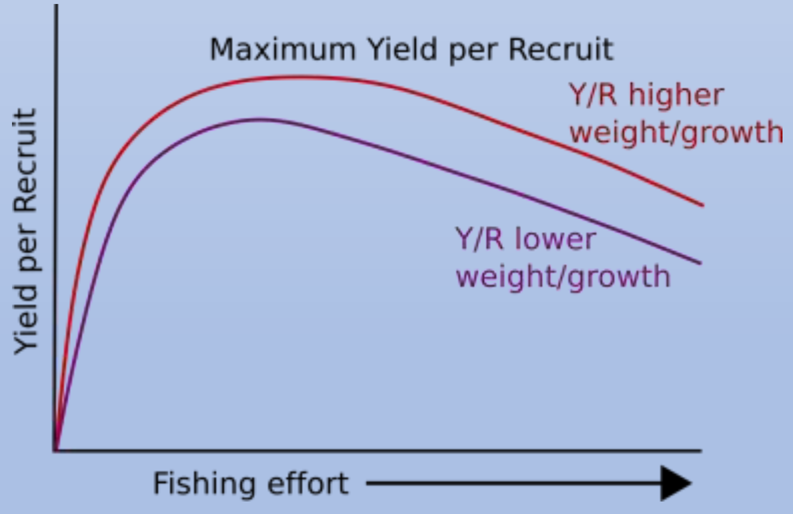
Growth overfishing

Definition: harvesting fish at too small a size, before they have reached their full growth potential.

Growth overfishing occurs when the average age or size of capture is too small. This means that increases in fishing effort and fishing mortality will result in decreasing yields.

A difference in growth or the age of capture can effect the **yield per recruit**. Allowing the fish to reach an older age before capture, or if growth is increased, the Y/R will be greater.

Yield per recruit is defined as the average expected yield in weight from a single recruit. This is affected by the growth rates, natural mortality, the maximum weight of the species, the age at first capture and fishing mortality. Using these inputs, scientists can calculate the average weight of fish available to the fishery from each recruit to the fishery. By changing the inputs, they can calculate what combinations of fishing mortality and age at first capture results in the **maximum sustainable yield**. With the addition of economic data, the **maximum economic yield** can be calculated.



Growth overfishing can not only impact on the **sustainability** of a **stock**, it can also decrease the **profitability** of the fishery. It can cost more to catch and process smaller fish, and for some species smaller fish attract a smaller market price.

One way of reducing the chance of growth overfishing is to use mesh or hook sizes that allow smaller fish to escape.

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Stock assessment

Recruitment overfishing

Definition: harvesting fish at a rate that will reduce the **spawning biomass** to a point where the level of **recruitment** does not replenish the **stock** lost through **mortality**.

Recruitment overfishing occurs when:

Fishing mortality (***F***) is too high, reducing the spawning stock biomass

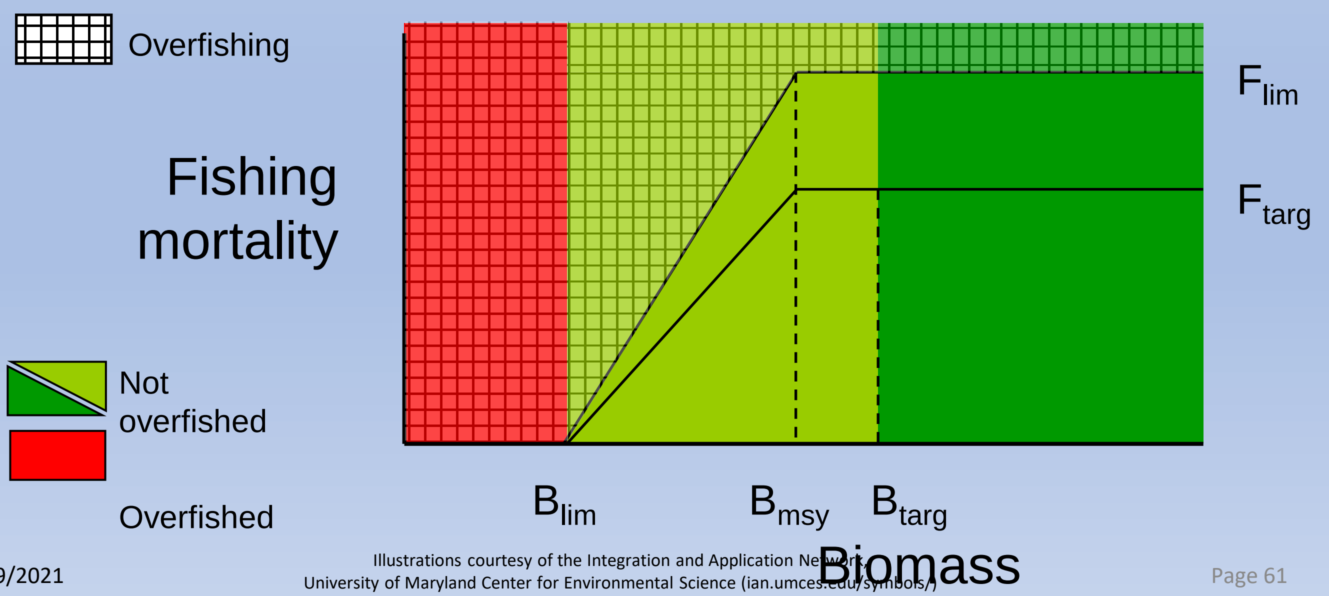
Fishing decreases the older proportion of the catch (best spawners)

Lowers recruitment in subsequent years

Recruitment overfishing can lead to a **stock decline** and, if it continues, the fishery can be classified as **recruitment overfished**. If this happens, increased management measures may be used to recover the stock.

How do we know if recruitment overfishing is occurring?

Classification of a **stock** as either **overfishing is occurring** or **overfishing is not occurring** generally requires information on the level of **fishing mortality**. For **data rich** species with agreed **quantitative stock assessments**, this is done by comparing to **fishing mortality**, to that which will achieve $\mathbf{B_{LIM}}$, called $\mathbf{F_{LIM}}$. If **fishing mortality** is higher than called $\mathbf{F_{MEY}}$ then the stock is classified as **overfishing is occurring**. Another measure sometimes used in comparing **fishing mortality** to **natural mortality**. If ***F*** is higher than ***M*,** then the stock is classified as **overfishing is occurring**.



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