Mortality

— Total Mortality —

Meaning: The rate that fish are killed both from natural causes (predation, old age, disease) and from fishing.

Symbol: ***Z***

Total mortality is the rate that fish die each year by natural causes (***M***) and fishing (***F***) combined. It is usually report as a proportion (e.g. 0.3 per year).

$$Z = M + F$$

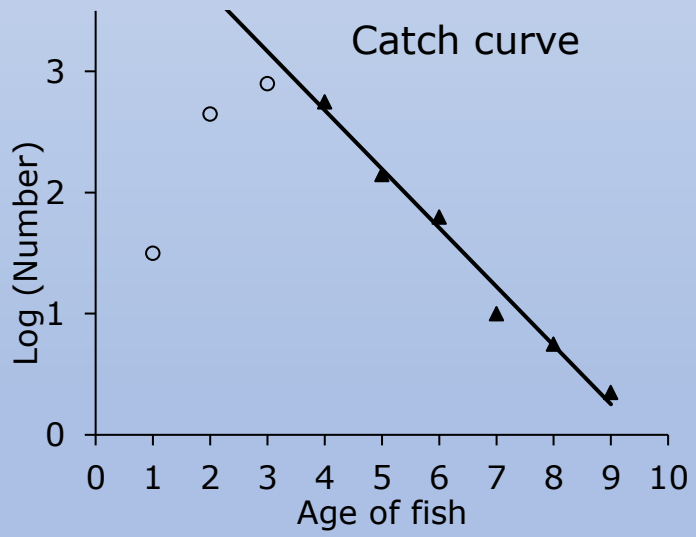
Total mortality is often calculated by a **stock assessment models**, but it can be estimated using other methods.

The most common method used to estimate **total mortality** directly is using **catch curves**. By assuming that the rate of mortality is constant across age classes, the rate of decrease (called the gradient or slope) in the relative number of fish at each **age** is the **total mortality** rate.

Catch curves only use only fish of an **age** that is fully selected by the fishing gear (solid triangles).

Using the logged number of fish straightens out a line that would otherwise be curved.

In this case, the slope of the line, and so the ***Z***, is 0.5.



Together, ***Z, M*** and ***F*** are some of the most important parameters for fishery stock assessments.

Mortality

— Fishing Mortality —

Meaning: The part of the total mortality rate that is due to fishing.

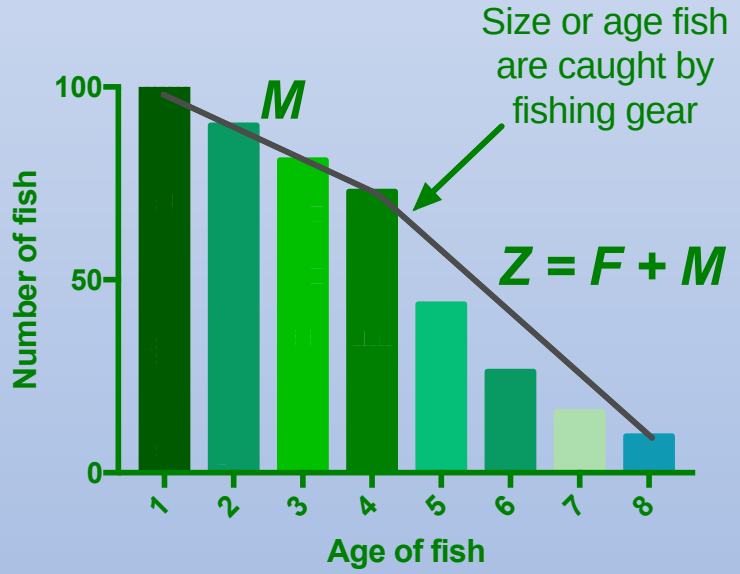
Symbol: ***F***

Fishing mortality is the rate that fish are **taken by fishing** each year. It is usually report as a proportion (e.g. 0.2 per year).

F can be estimated by dividing the catch (***C***) by the mean stock size or biomass (***B***).

$$F = \frac{C}{B}$$

If ***F*** = 0.30, then 30% of the population is caught a year. However, this is added to the *natural mortality* for the total effect on the population.



F can vary due to the biological characteristics of the species and the gear used in the fishery.

F can be difficult to measure directly, especially if **biomass** is unknown. ***F*** is often calculated by the assessment model, and is one of the model parameters that can be changed to test the effect different rates of fishing on future **biomass,** as a part of a process called **management strategy evaluation (MSE).**

Illustrations courtesy of the Integration and Application Network, University of Maryland Center for Environmental Science (ian.umces.edu/symbols/)

Mortality

— Fishing Mortality—

Fishing mortality can be referred to in a number of different ways, particularly in relation to a **harvest strategy** or **management strategy evaluation.**

$\mathbf{F_{LIM}}$ – the fishing mortality that above which is considered too high.

$\mathbf{F_{MEY}}$ – the fishing mortality that corresponds to the **maximum economic yield**.

$\mathbf{F_{MSY}}$ – the fishing mortality that corresponds to the **maximum sustainable yield**.

$\mathbf{F_{TARG}}$ – the target fishing mortality rate.

$\boldsymbol{F_{20}}$ – the rate of fishing mortality at which the spawning biomass is reduced to 20 percent of its unfished level;

$\boldsymbol{F_{F:M}}$ – the rate of fishing mortality at which the sex ratio (females per male) is double that in an unfished state.

Illustrations courtesy of the Integration and Application Network,
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Mortality
— Catchability —

Meaning: The portion of the stock caught by a unit of fishing effort

Symbol: q

Fishing mortality can depend on *effort* and "*catchability*":

$$F = q \times f$$

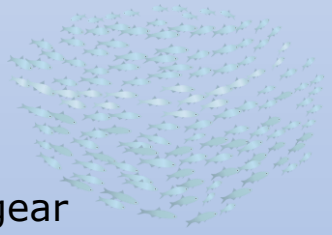
where f is **annual fishing effort** and q is an estimate of the **catchability** of the species.

Catchability can mean several things:

- How efficient is the fishing gear? What is the fishing power?
- Is the fishing gear size selective?
- Fish caught per fish available per effort unit per time unit
- What is the probability a fish will get caught?

Catchability will depend on:

- How many fish are available
- How fish behave towards fishing gear
- Size of the fish
- Season, age, environment & other species
- Gear type: design, mesh/hook size, material
- Fisher experience & gear handling



Do the fish school? Do fish swim close to the bottom? Do they have a natural escape response?

How many hooks or traps are used?

If q changes over time or space, then changes in CPUE can be mistaken for changes in abundance.

Mortality

— Natural Mortality —

Meaning: The part of the total mortality rate that is due to natural causes (predation, old age, disease).

Symbol: ***M*** 

Natural mortality is the rate that fish **die by natural causes** each year. These causes include dying of old age, predation, competition, cannibalism, starvation, pollution or disease. Natural mortality can be selective, such as older fish might be more susceptible to disease. It is usually report as a proportion (e.g. 0.3 per year).

What affects natural mortality?

- **Density**: in more crowded populations disease may spread quickly.
- **Environment**: dramatic changes in salinity or temperature may cause mass die-offs of fish. Environmental changes may result in toxic algae blooms or loss of food sources, contributing to higher ***M***.
- **Life cycle**: Natural mortality rates may not be constant throughout a fish's life. Fish may be more susceptible to dying at younger or older stages. But for stock assessments, an "average" natural mortality rate is used.

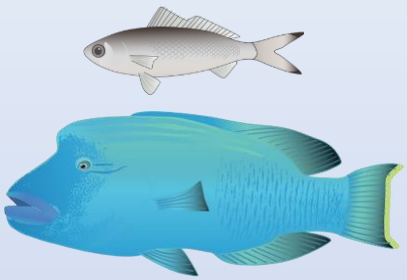
Natural mortality is hard to measure, especially in a stock that is fished. But there are a number of methods that can be used to calculate ***M***, and these are described in a different section.

Mortality

— Estimating Natural Mortality —

While natural mortality is hard to measure, there are some general relationships that allow us to estimate ***M***.

Perhaps the simplest of these is that in general, animals that live a long time have low rates of ***M***, while animals that live short lives have high rates of ***M***.



T_{max}=12 y, ***M***=0.4

T_{max}=32 y, ***M***=0.1

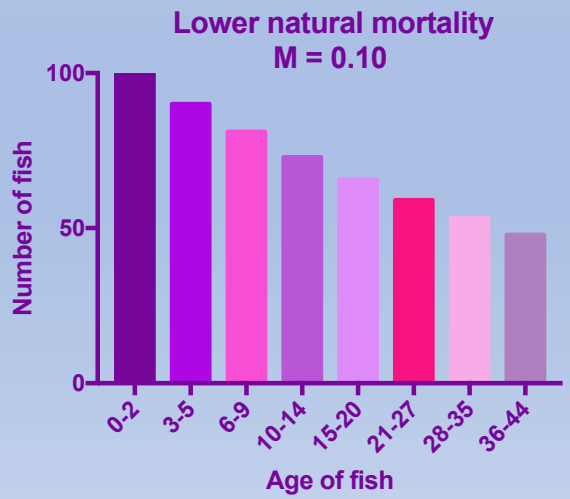
By studying the **natural mortality** and maximum age (T_{max}) of lots of species, fishery scientists . One example is:

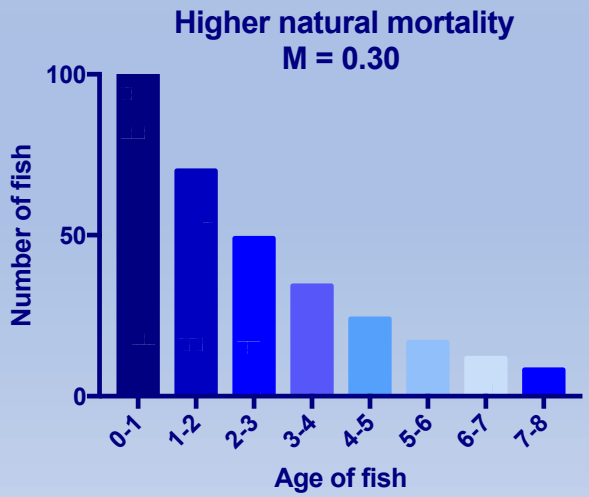
$$M = \frac{4.22}{Tmax}$$

Other fishery scientists have linked **natural mortality** to **von Bertallanfy** growth curve parameters, water temperature, **age at maturity**, reproductive effort and weight.

Species with low natural mortality may have generally steady population numbers, with low birth levels and slow growth rates.

Species with high natural mortality might have higher birth or recruitment levels to counter high natural mortality. Often species with high ***M*** will have populations that can more easily fluctuate.





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