Stock Status Plots (SSP)

Overfishing occurs in fisheries that have been exploited at levels that exceed the capacity for replacement by reproduction and growth of the exploited species (Ricker, 1975; Grainger, 1999). Species that are being overfished are producing catches that are below the level that could be sustainably derived. As a result of intense exploitation, most fisheries generally follow sequential stages of development: *undeveloped*, *developing*, *fully exploited*, *overfished*, and *collapsed*. Buildingg thereon, Grainger and Garcia (1996) conceived the first version of the *Stock Status Plots* (SSP) by fitting time series of landings with polynomials, and classifying their slopes, i.e.:

1. flat slope at a minimum: undeveloped;
2. increasing slopes: developing fisheries;
3. flat slope at a maximum: fully exploited;
4. decreasing slopes: senescent fishery (collapsed).

This led to graph such as Figure 1, which formed the basis for inferences on the status off global fisheries.

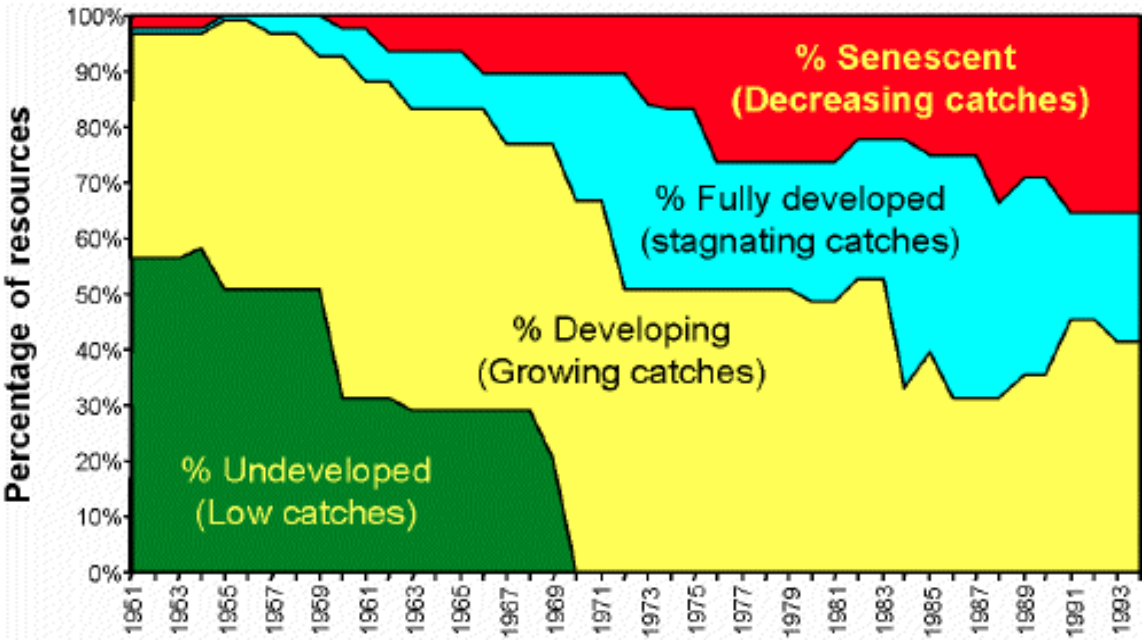

Figure 1. Evolution of the state of world resources from 1950-1994, based exclusively on statistical trends for 200 major stocks (Grainger and Garcia, 1996).

To simplify the approach of Grainger and Garcia (1996), Froese and Kesner-Reyes (2002) used designations for stock status that were based on the level of catch relative to the maximum catch during the entire period that the stock had been exploited. As this approach did not involve fitting polynomials to the catch time series, many more species could be evaluated. They defined the status of over 900 stocks using the criteria illustrated in Figure 2, i.e., *undeveloped*, *developing*, *fully exploited*, *overfished*, or *collapsed* (see also Table 1).

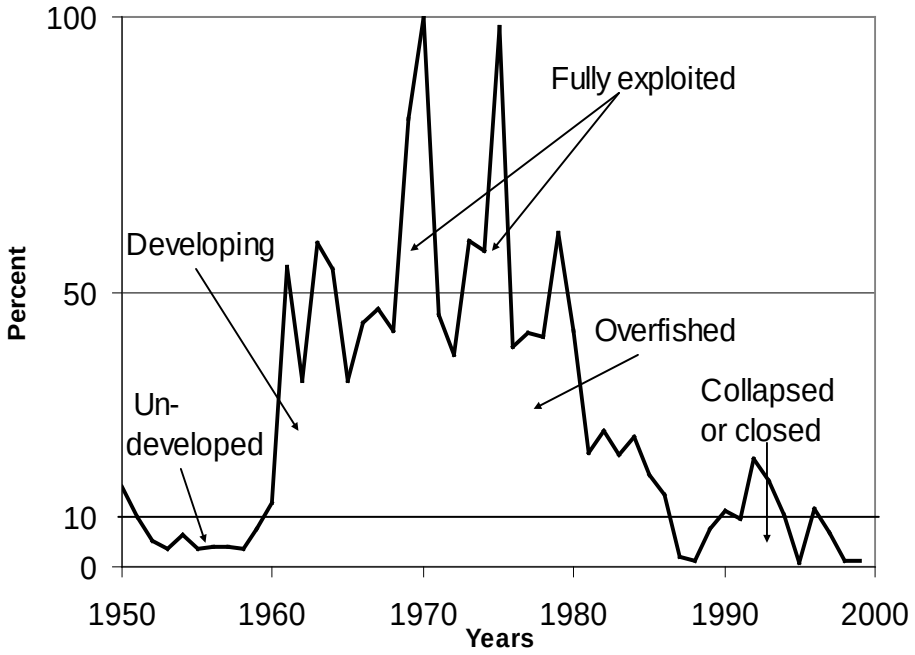

Figure 2. Typical transition of a fishery as illustrated by a time series of catch data (here for the basking shark *Cetorhinus maximus*), from *undeveloped* through *fully exploited*, to *collapsed*, (or *closed*). See Table 1 for definition of these stages. (Adapted from f Froese and Kesner-Reyes (2002).

Table 1. Criteria used to assign development stages to fisheries in FAO production data time series based on Froese and Kesner-Reyes (2002).

Status of fishery	Criterion applied
Undeveloped	Year before maximum production and production less than 10% of maximum value.
Developing	Year before maximum production and production 10-50% of maximum value.
Fully exploited	Production larger than 50% of maximum value.
Overfished	Year after maximum production and production 10-50% of maximum value.
Collapsed/Closed	Year after maximum production and production less than 10% of maximum value.

The stock-status plots (SSPs) presented on the *Sea Around Us* website build on the work of Grainger and Garcia (1999) and Froese and Kesner-Reyes (2002), but addresses several criticisms of the original approaches. First, the original plots did not account for the fact that newly exploited stocks might be considered *developing* if their landings have not reached a peak by the most recent year of exploitation. Therefore, we count all stocks that have a peak in catch (maximum catch) in the final year of the time series as *developing.* Secondly, we merge the *undeveloped* and *developing* categories, as we assume that any fishery undergoing even low exploitation as being developed. Finally, we account for stock recovery, which has occurred in well-managed fisheries, through an additional category called *rebuilding*.

The *Sea Around Us'* SSPs are created in four steps (Kleisner and Pauly, 2011). The first step is the definition of a stock. We define a stock to be a taxon (either at species, genus or family level of taxonomic assignment) that occurs in the catch records for at least 5 consecutive years, over a minimum of 10 years time span, and which has a total catch in an area of at least 1000 tonnes over the time span. Secondly, we assess the status of the stock for every year, relative to the peak catch. We define five states of stock status for a catch time series. This definition is assigned to every taxon meeting the definition of a stock for a particular spatial area considered (e.g., EEZ, LME).

1. *Developing* - before the year of peak catch and less than 50% of the peak catch;
2. *Exploited* - before or after the year of peak catch and more than 50% of the peak catch;
3. *Overexploited* - after the year of peak catch and less than 50% but more than 10% of the peak catch;
4. *Collapsed* - after the year of peak catch and less than 10% of the peak catch;
5. *Rebuilding* - occurs after the year of peak catch and after the stock has collapsed (after the post-maximum minimum catch, Figure 3), when catch has recovered to between 10% and 50% of the peak.

Thirdly, we create the graph of *number of stocks by status* by tallying the number of stocks in a particular state in a given year, and presenting these as percentages. Finally, the cumulative catch of stock by status in a given year is summed over all stocks and presented as a percentage in the *catch by stock status* graph, or stock-catch-status plot (SCSP). The combination of these two figures represents the complete SSP (Figure 3).

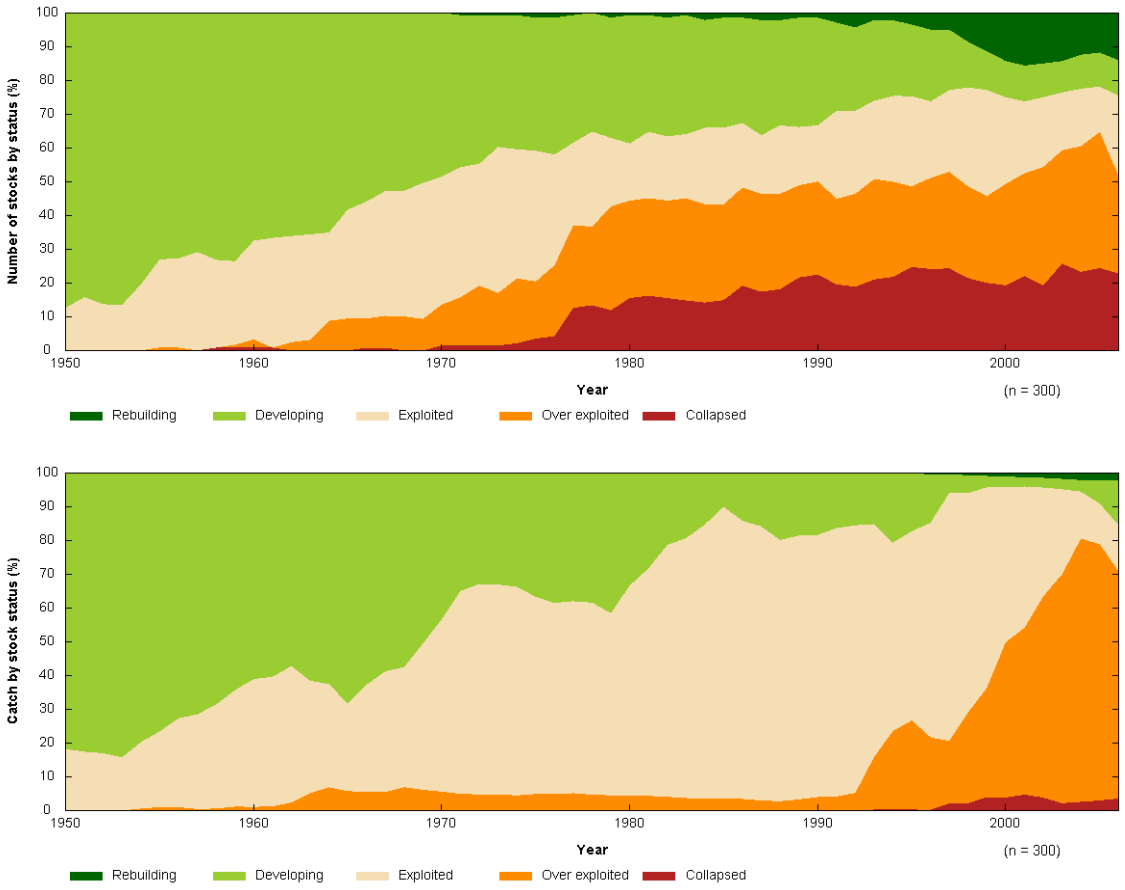

Figure 3. Example of a Stock Status plot as defined by the *Sea Around Us* Project for the Kuroshio Current LME; note rebuilding stocks in the upper right corners of the graphs (see text).

The *number of stocks by status* graph illustrates the typically increasing number of stocks that are considered overfished or collapsed. The *catch by stock status* graph demonstrates that often we are taking the bulk of catches from an increasingly smaller number of stocks, as more stocks become overfished or collapsed. Jointly, these two graphs, and hence the SSP points to an increase in stocks that are compromised, and a decrease in the biodiversity of exploited fishery resources, both in the above example, and in the world in general.

References:

Froese, R., Kesner-Reyes, K., 2002. Impact of fishing on the abundance of marine species. ICES CM 2002/L: 12, 15 p.

Grainger, R.J.R. 1999. Global trends in fisheries and aquaculture. p. 21-25 *In* National Ocean Service, NOAA, Center for the Study of Marine Policy at the University of Delaware, The Ocean Governance Group. 1999. Trends and Future Challenges for US National Ocean and Coastal Policy: Workshop Materials. Washington, D.C.

Grainger, R.J.R., and Garcia, S., 1996. Chronicles of marine fisheries landings (1950-1994): trend analysis and fisheries potential. FAO Fish. Tech. Pap. 359, 51 p.

Kleisner, K. and Pauly, D. 2011. Stock catch status plots of fisheries for regional seas. *In* Christensen, V., Lai, S., Palomares, M.L.D., Zeller, D. and Pauly, D. (Eds.). The State of Biodiversity and Fisheries in Regional Seas. Fisheries Centre Research Reports

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Canada 191, 382 p.