Productivity and Susceptibility Analysis (PSA): How-To Guide

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Intro

The Productivity and Susceptibility Analysis is used to assess the risk, or vulnerability, of a stock to fishing pressure based on both biological productivity and stock susceptibility to fishing. The only data inputs are life history parameters such as age at first maturity, maximum age, fecundity, natural mortality, and behavior – easily available from local fishermen, literature, and online databases such as FishBase – and information on the fishery available from fishermen and managers. No catch records, effort information, or fishery-independent surveys are necessary.

Productivity, or the potential growth rate of the population, is ranked from low to high on a scale of 1-3 using a combination of parameters such as natural mortality and fecundity. Susceptibility of the stock to fishing pressure is also scaled from low to high on a scale of 1-3. Susceptibility is based on a variety of factors, including current management practices, an estimated fishing mortality rate (including discards), and species behavior, such as schooling and seasonal migrations, which may alter catchability of the stock. The final vulnerability score is tabulated by combining both the productivity and susceptibility scores. Vulnerability rankings can be used to prioritize management and to guide basic management decisions (e.g., ban harvest of very vulnerable species, or increase harvest of resilient species).

When working in a multispecies fishery it may be tempting to try to group species together and only apply a PSA to one representative from each group (e.g. one representative grouper). However, we strongly advise against doing this. Although applying the PSA to every species caught by the fishery (both targets and non-targets) may take a relatively large amount of time and capacity, assuming one species can represent others without having an understanding of each of their individual life history characteristics and relationships with the fishery is very risky. This is because individual species within a family or class can still have drastically different productivity and susceptibility characteristics, and management decisions made based on the PSA results for one species may not be sufficient to prevent overfishing of another. For this reason we recommend applying the PSA to each species impacted by the fishery. Once this assessment has been completed, the resulting vulnerability scores can be used to make a more informed decision about how to group species for further assessment and management, if necessary.

The following describes a step-by-step guide for conducting the PSA.

Gathering Data

1. Target Species

a. Choose the target species/stocks you wish to include in the analysis. The PSA is more manageable if you keep the list relatively small (i.e., 20 species).
2. Excel Spreadsheet
   a. Use the Excel spreadsheet to keep track of the parts of the analysis. Productivity attributes are on the top half of the spreadsheet; susceptibility attributes are on the bottom. There are columns to enter the raw data, the data source, weight (see below), attribute score, and data quality score (see below).
3. Gathering Productivity Data
   a. Gather data on the biology of each species, either from literature, local fishermen, or online databases. If data is not available, information from similar species can be used. This information is used to determine the productivity of each species.
   b. Productivity attributes:
      i. r (population growth)
      ii. Max age
      iii. Max size
      iv. von Bertalanffy growth coefficient (k)
      v. Estimated natural mortality (M)
      vi. Measured fecundity
      vii. Breeding strategy
      viii. Recruitment Pattern
      ix. Age at maturity
      x. Mean trophic level
   c. Example:
      i. Napoleon wrasse (*Cheilinus undulates*) has a maximum age of 32 years, so it gets a Maximum Age attribute score of **1** (>30 yrs).
4. Gathering Susceptibility Data
   a. Gather data on the fishery itself, either from fishermen or managers. This information is used to determine the susceptibility of target species to overfishing.
   b. Susceptibility attributes:
      i. Management strategy
      ii. Areal overlap
      iii. Geographic concentration
      iv. Vertical overlap
      v. Fishing rate relative to M
      vi. Biomass of spawners (SSB) or other proxies
      vii. Seasonal migrations
      viii. Schooling/Aggregation
      ix. Morphology affecting capture
      x. Survival after capture and release
      xi. Desirability/value of the fishery
      xii. Fishery impact to essential fish habitat (EFH) or habitat in general for non-targets
   c. Example:
      i. Napolean wrasse (*Cheilinus undulates*) aggregate to spawn, so it gets a Schooling/Aggregation attribute score of **3** (behavioral responses increase the catchability of the gear).

Weighting System

Each productivity and susceptibility attribute is weighted on a scale of 0-4. Depending upon the species, some parameters may be more or less useful for determining the vulnerability of the stock.

It is recommended to give all attributes a weight of 2 unless there are specific reasons to do otherwise. Giving an attribute a score of 0 will remove it entirely from the analysis. If an attribute is removed from the analysis for one species it should be removed from the PSA for all species.

Data Quality Scores

The PSA accounts for varying levels of data quality, ranging from no data to data gathered from a full stock assessment. More reliable, robust data are given a score of one, whereas complete absence of data is given a score of five. The data quality index helps incorporate uncertainty into the analysis and provides additional information to managers. For example, data-poor stocks might receive inflated vulnerability scores due to lack of information; the data quality parameter is intended to correct for this.

Data quality definitions can be found on the second tab in the Excel spreadsheet.

PSA Software

The PSA software can be downloaded for free here: http://nft.nefsc.noaa.gov/Download.html

The Help tab is a good resource for additional information and specifics on how to use the software.

Entering Data into Software

1. Open a new database.
2. Under the Tools tab, go to *Stock List Maintenance*.
3. Enter the *Stock Name* (species name) and *Scientific Name* of your first target species. Click *Add*.
4. Repeat for the rest of the species in the analysis. The order in which they appear in the analysis can be changed by altering the *Pull Down List Order* number.
5. Click *Data Grid* in the tool bar.
6. Click the button *Add Stock to Grid*.
7. From the pull-down menu above the *Attribute Score* box, choose a species to add to your analysis.
8. Repeat steps 6 and 7 to add the rest of the species to the Data Grid.
9. Using the Excel spreadsheet as a reference, enter the attribute scores, weight, and data quality score for each species.
10. Save the analysis by clicking the *Save Data and Refresh Open Plots/Reports* button.

Graphs and Reports

1. Once all the scores have been added to the Data Grid, click the *Plots* tab, and then *New*. The total vulnerability scores for all species in the PSA will be plotted onto a graph – productivity is on the x-axis and susceptibility is on the y-axis. The color of the dots relates to the data quality score (see the graph's legend).
2. Species in the upper right quadrant of the graph are highly susceptible to overfishing and have low productivity, which means they are highly vulnerable. Species in the lower left quadrant of the graph have a low susceptibility and high productivity, meaning their vulnerability is likely low.
3. The numbers on the graph relate to the record number of each species. This can be found in the report (see below).
4. The contour lines can be altered to reflect equal regions denoting similar vulnerability levels.
   a. To change the contour lines, click the *Options* tab. Changing the *Score* of each line changes where it lands on the graph. The color of each contour line can also be changed.
   b. Example: the Indonesia PSA has contour lines at regular intervals, 0.5 apart (e.g., 2.75, 2.25, etc.), dividing the PSA output chart into six equal regions.
5. Click the *Reports*, and *New* tab to get full and summary data reports of the PSA, showing total productivity, susceptibility, vulnerability, data quality scores, standard deviation, and number of attributes used for each species. Reports also show the record number for each species; these numbers are shown in the plotted graph.
6. Graphs can be saved as bmp files and reports can be exported as csv files.