Determining the Vulnerability of Stocks

Vulnerability Evaluation Work Group

The Work Group

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Outline

- Definition of vulnerability
- How information on vulnerability can be used
- How vulnerability can be determined (productivity-susceptibility analysis)
- Results from six example applications in the U.S.
- Results from application to BSAI Alaska skates
- Conclusions

Definition of Vulnerability

Goal – Provide technical guidance on how to determine the vulnerability of a stock to a fishery.

NS1 Guidelines describe vulnerability as "*a combination of its productivity, which depends upon its life history characteristics, and its susceptibility to the fishery*"

Vulnerability – our definition is "*the extent to which the productivity of the stock is diminished by targeted and indirect fishing pressure*" This is similar to definitions provided by Lenfest Ocean Program (2007) and Garcia and Staples (2000)

Use of Vulnerability

- Identifying Ecosystem Component stocks
- Identifying stock complexes
- Determining buffer between target and limit control rules

Identifying Ecosystem Component stocks

- Ecosystem stocks are defined in NS1 as non-target stocks that are:
  - not generally retained for sale or personal use
  - not be determined to be subject to overfishing, approaching overfished, or overfished
  - not be likely to become subject to overfishing or overfished, according to the best available information, in the absence of conservation and management measures
- Vulnerability analysis pertains to the last condition

Identifying stock complexes

- Stock complexes are defined in NS1 as "*a group of stocks that are sufficiently similar in geographic distribution, life history, and vulnerabilities to the fishery such that the impact of management actions on the stocks is similar.*"
- *An indicator stock is a stock with measurable status determination criteria that can be used to help manage and evaluate more poorly known stocks that are in a stock complex. If an indicator stock is used to evaluate the status of a complex, it should be representative of the typical status of each stock within the complex, due to similarity in vulnerability.*

Determining buffer between target and limit control rules

- The NS1 guidelines state that "*The ABC control rule must articulate how ABC will be set compared to the OFL based on the scientific knowledge about the stock or stock complex and the scientific uncertainty in the estimate of OFL and any other scientific uncertainty. The ABC control rule should consider uncertainty in factors such as stock assessment results, time lags in updating assessments, the degree of retrospective revision of assessment results, and projections.*"

Productivity-Susceptibility Analysis (PSA)

Vulnerability is measured as a function of the *productivity* of the stock and its *susceptibility* to the fishery. From NS1 guidelines:

Productivity – "*The capacity of the stock to produce MSY and to recover if the population is depleted.*"

Susceptibility – "*The potential for the stock to be impacted by the fishery, which includes direct captures, as well as indirect impacts to the fishery (e.g., loss of habitat quality).*"

This is an expansion from previously used definitions, which only considered direct capture.

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Elements of the PSA

Specific methodology differs slightly between authors, but most applications have the following general steps:

1) Identify and assign relative weights to attributes of productivity and susceptibility
2) Identify what species the method will be applied to (commonly all or several species captured by a fishery)
3) Gather data and rank the productivity and susceptibility attributes of each species, and compute the overall productivity and susceptibility scores.
4) Plot the productivity and susceptibility scores for each species, and compute vulnerability as a function of productivity and susceptibility.

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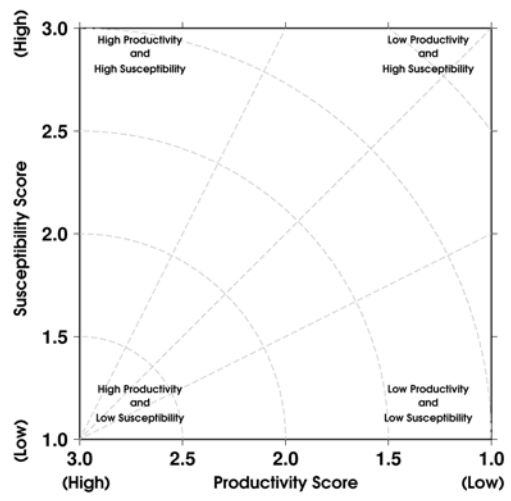
The PSA scatterplot



Vulnerability is measured as Euclidian distance

$$v = \sqrt{(p-3)^2 + (s-1)^2}$$

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Productivity Attributes

- Population growth rate (*r*)
- Maximum age
- Maximum size
- von Bertalanffy growth coefficient (k)
- Natural mortality
- Fecundity
- Reproductive biology (i.e. parental investment)
- Recruitment pattern
- Age at maturity
- Mean trophic level

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Susceptibility Attributes

Catchability

- Areal overlap with fishery
- Vertical overlap with fishery
- Seasonal migrations
- Geographic concentration (i.e., patchiness)
- Schooling/Aggregation or other behavioral responses
- Morphology affecting capture
- Desirability/value of fishery

Management

- Biomass of spawners
- Management Strategy
- F/M
- Survival after capture and release
- Fishery impact on habitat

Data Quality Index

Recent data for stock and area of interest

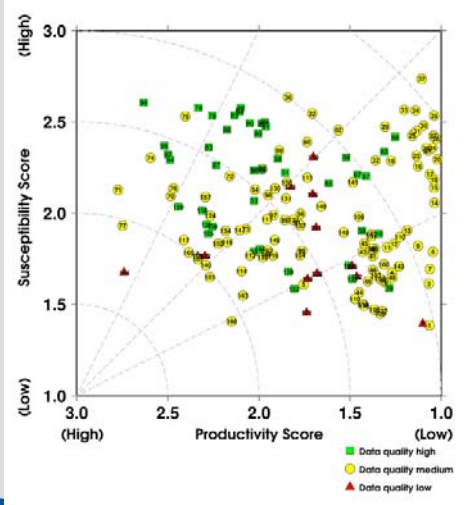
No data. Not included in PSA, but included in data quality index score

Previous applications have generally ignored overall uncertainty, and assumed the lowest level of productivity (or highest susceptibility) for attributes with missing data. This could lead to inaccurate characterizations of risk.

Example Applications (162 stocks)

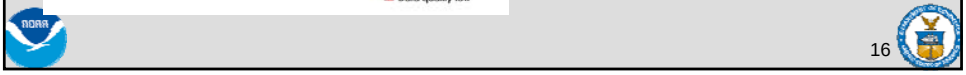
- Northeast Groundfish Multi-species Fishery (gadids, flatfish, other demersal stocks)
- Highly Migratory Atlantic Sharks
- California Nearshore Groundfish Finfish Assemblage (mostly rockfish)
- California Current Coastal Pelagic Species
- BSAI Skates
- Hawaii Longline Fishery (two sectors – tuna and swordfish)

Is there a clear line between potential ecosystem stocks and fishery stocks?

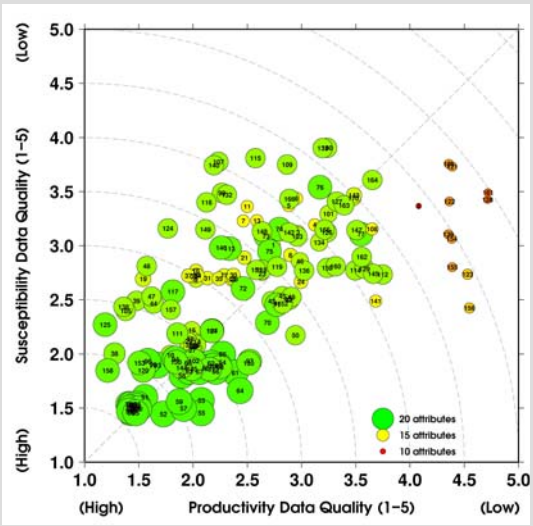


We were not able to identify a line that we felt would be generally applicable for a variety of applications

In three of the applications, the vulnerabilities of non-target stocks were not significantly different than those of target stocks



Data quality as a function of the number of attributes scored



Data quality increases as the number of missing attributes decreases

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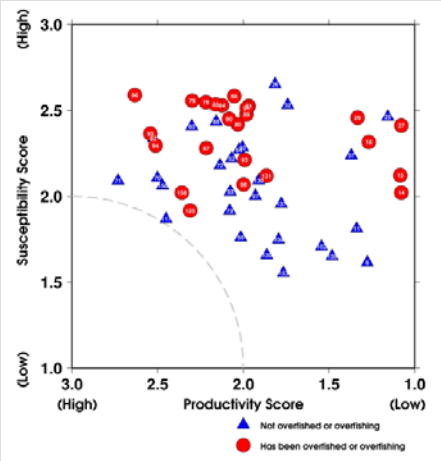
Do heavily fished stocks have higher vulnerability?



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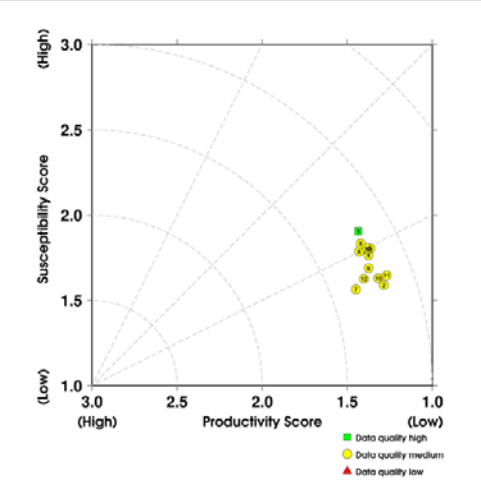
How does it work for a data poor stock?



BSAI skates

One species (Alaska skate) with much more data than others

Tightly clustered

NS1 defines complexes as a group similar in both their life-history characteristics and vulnerability. We can use PSA to evaluate this.

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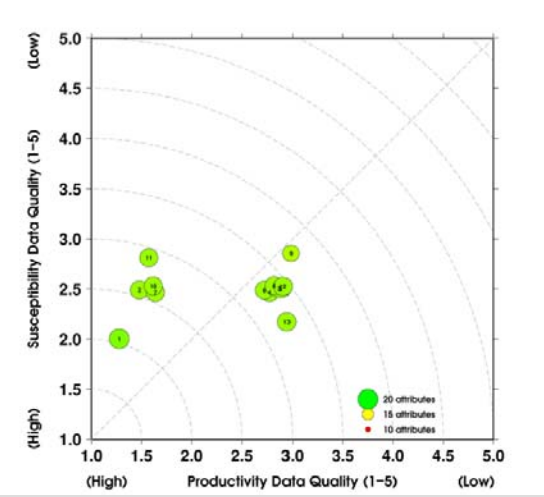
Data quality for BSAI skates



The data quality should be considered when making inferences about stocks.

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Conclusions/Recommendations

- Because PSA is somewhat subjective, it should be conducted by a panel to in order to fully consider a variety of views and reduce the influence of any particular individual
- Data quality should be considered in interpreting the PSA scores
- Complexes should show similarity on both the susceptibility and productivity axes.