# NMFS's Vulnerability Evaluation Work Group (VEWG) – Preliminary Findings

**VEWG Co-Leaders:** Wesley Patrick (OSF) and Paul Spencer (AKFSC)
**VEWG Members:** Jason Link (NEFSC), Bill Overholtz (NEFSC), Todd Gedamke (SEFSC), Enric Cortes (SEFSC), John Field (SWFSC), Pete Lawson (NWFSC), Jason Cope (NWFSC), Olav Ormseth (AKFSC), Don Kobayashi (PIFSC) and Keith Bigelow (PIFSC).
**Work Group Coordinators:** Rick Methot (OST) and Galen Tromble (OSF)

**Background.** NMFS has revised the guidelines for National Standard 1 (NS 1) of the Magnuson-Stevens Act, to comply with new annual catch limit and accountability measure requirements for ending overfishing in Federal fisheries as described in the Magnuson-Steven Reauthorization Act of 2006. Concurrently, several work groups (i.e., ABC/ACT Control Rules, National Standard 2, and Vulnerability Evaluations) have been created to produce reports on how to carry out new analytical requirements described in the NS 1 guidelines.

The Vulnerability Evaluation Work Group (VEWG) was developed to provide a methodology for determining the vulnerability of a stock. While determining the vulnerability of a stock is not a requirement of the MSRA, NOAA Fisheries believes this information will be useful in meeting the new ACL requirements. The proposed NS1 guidelines reference the term "vulnerability" in sections dealing with: 1) differentiating between stocks "in the fishery" and "ecosystem components"; 2) assembling and managing stock complexes; and 3) creating management control rules.

**Approach.** Tasked with providing a tool that is flexible in its use and comparable across fisheries and regions, the VEWG reviewed several risk assessment methods to determine which approach was best suited for the NS1 guidelines use of the term vulnerability. The Productivity and Susceptibility Assessment (PSA) was selected as the best approach for examining the vulnerability of stocks, because it can be based on qualitative data, has a history of use in other fisheries, and is recommended by several organizations and work groups as a reasonable approach for determining risk (Hobday et al. 2004, Smith et al. 2007, Rosenberg et al. 2007).

The PSA was originally developed to classify differences in bycatch sustainability in the Australian prawn fishery by evaluating the productivity of a stock to its susceptibility to the fishery (Stobutzki et al. 2001). The productivity and susceptibility of a stock was determined by providing a score ranging from 1 to 3 for a standardized set of attributes (N=13) related to each factor. The scores were then calculated for each factor and graphically displayed on an x-y scatter plot (Figure 1). Stocks that received a low productivity score and a high susceptibility score were considered to be the least sustainable (i.e., high vulnerability), while stocks with a high productivity score and low susceptibility score were considered to be the most sustainable (i.e., low vulnerability). The PSA was later modified in 2004 by the Australian Ecological Risk Assessment (AERA) team (Hobday et al. 2004), who expanded the structure of the PSA to include habitat and community components so that the tool could be used to assess the vulnerability of an ecosystem. Revisions to the PSA were also suggested in the Lenfest expert working group report on setting annual catch limits for U.S. fisheries (Rosenberg et al. 2007).

**Progress.** While the VEWG agreed that the PSA was an appropriate model in which to base their vulnerability evaluation, the work group has been meeting since January of 2008 to revise the methodology based on the proposed revisions of Hobday et al. (2004) and Rosenberg et al. (2007),

as well as making additional revisions to provide more flexibility for its use in diverse U.S. fisheries. Revisions include:

- Selecting an appropriate number of Productivity and Susceptibility attributes – As noted above the original PSA consisted of 13 attributes, but has since been expanded to 75+ attributes by Hobday et al. (2004) and Rosenberg et al. (2007). The VEWG found many of the attributes to be duplicative and/or uninformative for its purposes and has culled down this list to 22 attributes (Table 1 and 2).
- Redefining the scoring matrix to provide real world break points – Previous scoring matrices were biased towards Australian prawn fishery, and are currently being rescaled for U.S. Fisheries (Table 1 and 2).
- Developing a universal weighting system – PSA have only been applied to Australian/New Zealand trawl fisheries; thus, their recommended weighting system is not applicable to other fisheries (e.g., gill net and long line fisheries). Our work group has suggested using a 0 – 4 weighting system with a default weighting of 2, which can be upgrade or downgraded by users based on the fishery.
- Developing a Data Quality Index – Ecological risk assessments have often applied the precautionary principle in data poor situations, by providing higher level risk scores when data is missing. While this approach avoids type II errors, this scoring process can result in risk scores becoming over-inflated (Hobday et al. 2004), leading to overly conservative management measures. The VEWG developed a data quality index that provides an estimate of uncertainty for individual vulnerability scores and is based on five tiers of data quality ranging from best data to no data (Table 3). The data quality of a vulnerability score will be displayed within the x-y scatter plot of productivity and susceptibility (Figure 1), as well as a separate x-y scatter plot comparing the productivity and susceptibility data quality scores (Figure 2).
- Addressing different sectors and gear types - as noted earlier, the PSA was first developed to evaluate the sustainability of bycatch species in the Australian prawn trawl fishery. The VEWG concluded that each sector of a fishery should have its own vulnerability evaluation performed to determine which stocks in that sector are most vulnerable. An overarching vulnerability evaluation score could be calculated for each stock listed in an FMP using a weighting system based on the sectors landings over some predetermined time frame (i.e., based on average landings).

The VEWG selected seven fisheries (i.e., Northeast Multispecies Groundfish, Atlantic Shark Complexes, South Atlantic/Gulf of Mexico Snapper-Grouper Longline Fishery, California Coastal Pelagics, California Nearshore Groundfish, Bering Sea/Aleutian Island Skate Complex, and the Hawaiian Pelagic Longline Fishery) to evaluate the effectiveness of its vulnerability evaluation. Overall 166 stocks were examined, and the results provided some interesting trends in vulnerability scores (Table 4; Figure 1). The work group is in the process of finalizing its report and expects to make it available to the public in April of 2009.

**Literature Cited:**

Hobday, A., T. Smith, and I. Stobutzki. 2004. Ecological risk assessment for the effects of fishing: methods. Final Report to the Australian Fisheries Management Authority, Canberra, Australia. Case Study 22/7/04 v7.

Rosenberg, A., D. Agnew, E. Babcock, A. Cooper, C. Mogensen, R. O'Boyle, J. Powers, G. Stefansson, and J. Swasey. 2007. Setting annual catch limits for U.S. fisheries: An expert working group report. Lenfest Ocean Program, Washington, D.C.

A. D. M. Smith, E. J. Fulton, A. J. Hobday, D. C. Smith, and P. Shoulder. 2007. Scientific tools to support the practical implementation of ecosystem-based fisheries management. ICES 64: 633-639.

Stobutzki, I., M. Miller, and D. Brewer. 2001. Sustainability of fishery bycatch: a process for assessing highly diverse and numerous bycatch. Environmental Conservation 28: 167-181.

**Table 1. A preliminary list of NMFS's productivity attributes and proposed scoring thresholds.**

| | Ranking | | |
|---|---|---|---|
| **Productivity Attribute** | **High (3)** | **Moderate (2)** | **Low (1)** |
| **r** | >0.5 | 0.16-0.5 | <0.16 |
| **Maximum Age** | < 10 years | 10 - 30 years | > 30 years |
| **Maximum Size** | < 60 cm | 60 - 150 cm | > 150 cm |
| **von Bertalanffy Growth Coefficient (k)** | > 0.25 | 0.15-0.25 | < 0.15 |
| **Estimated Natural Mortality** | > 0.40 | 0.20 - 0.40 | < 0.20 |
| **Measured Fecundity** | > 10e4 | 10e2-10e3 | < 10e2 |
| **Breeding Strategy** | 0 | between 1 and 3 | ≥4 |
| **Recruitment Pattern** | highly frequent recruitment success (> 75% of year classes are successful) | moderately frequent recruitment success (between 10% and 75% of year classes are successful) | infrequent recruitment success (< 10% of year classes are successful) |
| **Age at Maturity** | < 2 year | 2-4 years | > 4 years |
| **Mean Trophic Level** | <2.5 | between 2.5 and 3.5 | >3.5 |

**Table 2. A preliminary list of NMFS's susceptibility attributes and proposed scoring thresholds.**

| Susceptibility Attribute | Ranking | | |
|---|---|---|---|
| | **Low (1)** | **Moderate (2)** | **High (3)** |
| **Management Strategy** | Targeted stocks have catch limits and proactive accountability measures; non-target stocks are closely monitored. | Targeted stocks have catch limits and reactive accountability measures | Targeted stocks do not have catch limits or accountability measures; non-target stocks are not closely monitored. |
| **Areal Overlap** | < 25% of stock occurs in the area fished | Between 25% and 50% of the stock occurs in the area fished | > 50% of stock occurs in the area fished |
| **Geographic Concentration** | stock is distributed in > 50% of its total range | stock is distributed in 25% to 50% of its total range | stock is distributed in < 25% of its total range |
| **Vertical Overlap** | < 25% of stock occurs in the depths fished | Between 25% and 50% of the stock occurs in the depths fished | > 50% of stock occurs in the depths fished |
| **Fishing rate relative to M** | <0.5 | 0.5 - 1.0 | >1 |
| **Biomass of Spawners (SSB) or other proxies** | B is > 40% of B0 (or maximum observed from time series of biomass estimates) | B is between 25% and 40% of B0 (or maximum observed from time series of biomass estimates) | B is < 25% of B0 (or maximum observed from time series of biomass estimates) |
| **Seasonal Migrations** | Seasonal migrations decrease overlap with the fishery | Seasonal migrations do not substantially affect the overlap with the fishery | Seasonal migrations increase overlap with the fishery |
| **Schooling/Aggregation and Other Behavioral Responses** | Behavioral responses decrease the catchability of the gear | Behavioral responses do not substantially affect the catchability of the gear | Behavioral responses increase the catchability of the gear [i.e., hyperstability of CPUE with schooling behavior] |
| **Morphology Affecting Capture** | Species shows low selectivity to the fishing gear. | Species shows moderate selectivity to the fishing gear. | Species shows high selectivity to the fishing gear. |
| **Survival After Capture and Release** | Probability of survival > 67% | 33% < probability of survival < 67% | Probability of survival < 33% |
| **Desirability/Value of the Fishery** | stock is not highly valued or desired by the fishery (< $1/lb; < $500K/yr landed; < 33% retention) | stock is moderately valued or desired by the fishery ($1 - $2.25/lb; $500k - $10,000K/yr landed; 33-66% retention) | stock is highly valued or desired by the fishery (> $2.25/lb; > $10,000K/yr landed; > 66% retention) |
| **Fishery Impact to EFH or Habitat in General for Non-targets** | Adverse effects absent, minimal or temporary | Adverse effects more than minimal or temporary but are mitigated | Adverse effects more than minimal or temporary and are not mitigated |

**Table 3. A preliminary list of NMFS's data quality tiers.**

| Data Quality Score | Description | Example |
|---|---|---|
| 1 | (Best data) Information is based on collected data for the stock and area of interest that is established and substantial. | Data rich stock assessment, published literature that uses multiple methods, etc. |
| 2 | (Adequate Data) Information with limited coverage and corroboration, or for some other reason deemed not as reliable as Tier 1 data | Limited temporal or spatial data, relatively old information, etc |
| 3 | (Limited Data) Estimates with high variation and limited confidence and may be based on similar taxa or life history strategy. | Similar genus or family, etc. |
| 4 | (Very Limited Data) Expert opinion or based on general literature review from wide range of species, or outside of region | General data – not referenced |
| 5 | (No Data) No information to base score on – not included in the PSA, but included in the DQI score. | |

**Table 4. The list of 166 stocks that were evaluated by the Vulnerability Evaluation Work Group.**

| ID | Fishery | Stock | Scientific name |
|---|---|---|---|
| 1 | | Sixgill shark | *Hexanchus griseus* |
| 2 | | Sharpnose sevengill shark | *Heptranchias perlo* |
| 3 | | Bigeye sandtiger shark | *Odontaspis noronhai* |
| 4 | | Whale shark | *Rhincodon typus* |
| 5 | | Caribbean sharpnose shark | *Rhizoprionodon porosus* |
| 6 | | Angel shark | *Squatina dumeril* |
| 7 | | White shark | *Carcharodon carcharias* |
| 8 | | Basking shark | *Cetorhinus maximus* |
| 9 | | Sandtiger shark | *Carcharias taurus* |
| 10 | | Blue shark | *Prionace glauca* |
| 11 | | Smalltail shark | *Carcharhinus porosus* |
| 12 | | Nurse shark | *Ginglymostoma cirratum* |
| 13 | | Galapagos shark | *Carcharhinus galapagensis* |
| 14 | | Dusky shark | *Carcharhinus perezi* |
| 15 | | Porbeagle | *Lamna nasus* |
| 16 | | Common thresher shark | *Alopias vulpinus* |
| 17 | | Oceanic whitetip shark | *Carcharhinus longimanus* |
| 18 | | Blacknose shark | *Carcharhinus acronotus* |
| 19 | Atlantic Shark Complexes | Lemon shark | *Negaprion brevirostris* |
| 20 | | Shortfin mako shark | *Isurus oxyrinchus* |
| 21 | | Longfin mako shark | *Isurus retroflexus* |
| 22 | | Tiger shark | *Galeocerdo cuvier* |
| 23 | | Smooth hammerhead shark | *Sphyrna zygaena* |
| 24 | | Caribbean reef shark | *Carcharhinus perezi* |
| 25 | | Blacktip shark | *Carcharhinus limbatus* |
| 26 | | Scalloped hammerhead shark | *Sphyrna lewini* |
| 27 | | Sandbar shark | *Carcharhinus plumbeus* |
| 28 | | Bigeye thresher shark | *Alopias superciliosus* |
| 29 | | Finetooth shark | *Carcharhinus isodon* |
| 30 | | Night shark | *Carcharhinus signatus* |
| 31 | | Bignose shark | *Carcharhinus altimus* |
| 32 | | Bonnethead shark | *Sphyrna tiburo* |
| 33 | | Spinner shark | *Carcharhinus brevipinna* |
| 34 | | Bull shark | *Carcharhinus leucas* |
| 35 | | Great hammerhead shark | *Sphyrna mokarran* |
| 36 | | Atlantic sharpnose shark | *Rhizoprionodon terraenovae* |
| 37 | | Silky shark | *Carcharhinus falciformis* |
| 38 | | Alaska skate | *Bathyraja parmifera* |
| 39 | | Aleutian skate | *Bathyraja aleutica* |
| 40 | | Commander skate | *Bathyraja lindbergi* |
| 41 | | Whiteblotched skate | *Bathyraja maculata* |
| 42 | | Whitebrow skate | *Bathyraja minispinosa* |
| 43 | | Roughtail skate | *Bathyraja trachura* |
| 44 | BSAI Skate Complexes | Bering skate | *Bathyraja interrupta* |
| 45 | | Mud skate | *Bathyraja taranetzi* |
| 46 | | Roughshoulder skate | *Amblyraja badia* |
| 47 | | Big skate | *Raja binoculata* |
| 48 | | Longnose skate | *Raja rhina* |
| 49 | | Butterfly skate | *Bathyraja mariposa* |
| 50 | | Deepsea skate | *Bathyraja abyssicola* |
| 51 | | California sheephead | *Semicossyphus pulcher* |
| 52 | | Cabezon | *Scorpaenichthys marmoratus* |
| 53 | | Kelp greenling | *Hexigrammos decagrammus* |
| 54 | | Rock greenling | *Hexigrammos lagocephalus* |
| 55 | | California scorpionfish | *Scorpaena guttata* |
| 56 | | Monkyface prickelback | *Cebidichthys violaceus* |
| 57 | | Black rockfish | *Sebastes melanops* |
| 58 | | Black-and-yellow rockfish | *Sebastes chrysomelas* |
| 59 | | Blue rockfish | *Sebastes mystinus* |
| 60 | CA Nearshore Groundfish | Brown rockfish | *Sebastes auriculatus* |
| 61 | | Calico rockfish | *Sebastes dallii* |
| 62 | | China rockfish | *Sebastes nebulosus* |
| 63 | | Copper rockfish | *Sebastes caurinus* |
| 64 | | Gopher rockfish | *Sebastes carnatus* |
| 65 | | Grass rockfish | *Sebastes rastrelliger* |
| 66 | | Kelp rockfish | *Sebastes atrovirens* |
| 67 | | Olive rockfish | *Sebastes serranoides* |
| 68 | | Quillback rockfish | *Sebastes maliger* |
| 69 | | Treefish rockfish | *Sebastes serriceps* |
| 70 | | Pacific sardine | *Sardinops sagax* |
| 71 | | Northern anchovy | *Engraulis mordax* |
| 72 | | Pacific mackerel | *Scomber japonicus* |
| 73 | CA Current Pelagics | Jack mackerel | *Trachurus symmetricus* |
| 74 | | Market squid | *Doryteuthis opalescens* |
| 75 | | Pacific herring | *Clupea pallasii* |
| 76 | | Pacific bonito | *Sarda chiliensis* |
| 77 | | Pacific saury | *Cololabis saira* |

**Table 4 (continued).**

| ID | Fishery | Stock | Scientific name |
|---|---|---|---|
| 78 | | Gulf of Maine cod | *Gadus morhua* |
| 79 | | Georges Bank cod | *Gadus morhua* |
| 80 | | Gulf of Maine haddock | *Melanogrammus aeglefinus* |
| 81 | | Georges Bank haddock | *Melanogrammus aeglefinus* |
| 82 | | Redfish | *Sebastes marinus* |
| 83 | | Pollock | *Pollachius virens* |
| 84 | | Cape Cod/Gulf of Maine yellowtail flounder | *Limanda ferruginea* |
| 85 | | Georges Bank yellowtail flounder | *Limanda ferruginea* |
| 86 | | Southern New England yellowtail flounder | *Limanda ferruginea* |
| 87 | NE Groundfish | American plaice | *Hippoglossoides platessoides* |
| 88 | | Witch flounder | *Glyptocephalus cynoglossus* |
| 89 | | Gulf of Maine Winter flounder | *Pseudopleuronectes americanus* |
| 90 | | Georges Bank Winter flounder | *Pseudopleuronectes americanus* |
| 91 | | Southern New England/Mid-Atlantic winter flounder | *Pseudopleuronectes americanus* |
| 92 | | Gulf of Maine/Georges Bank windowpane | *Scophthalmus aquosus* |
| 93 | | Southern New EnglandMid-Atlantic windowpane | *Scophthalmus aquosus* |
| 94 | | Ocean pout | *Zoarces americanus* |
| 95 | | White hake | *Urophycis tenuis* |
| 96 | | Atlantic halibut | *Hippoglossus hippoglossus* |
| 97 | | Albacore | *Thunnus alalunga* |
| 98 | | Bigeye tuna | *Thunnus obesus* |
| 99 | | Black marlin | *Makaira mazara* |
| 100 | | Bullet tuna | *Auxis rochei rochei* |
| 101 | | Pacific pomfret | *Brama japonica* |
| 102 | | Blue shark | *Prionace glauca* |
| 103 | | Bigeye thresher shark | *Alopias superciliosus* |
| 104 | | Blue marlin | *Makaira nigricans* |
| 105 | | Dolphin fish (mahi mahi) | *Coryphaena hippurus* |
| 106 | | Brilliant pomfret | *Eumegistus illustris* |
| 107 | | Kawakawa | *Euthynnus affinis* |
| 108 | | Spotted moonfish | *Lampris guttatus* |
| 109 | | Longfin mako shark | *Isurus paucus* |
| 110 | | Salmon shark | *Lamna ditropis* |
| 111 | | Striped marlin | *Tetrapturus audax* |
| 112 | | Oilfish | *Ruvettus pretiosus* |
| 113 | HA Pelagic Longline - Swordfish | Northern bluefin tuna | *Thunnus orientalis* |
| 114 | | Roudi escolar | *Promethichthys prometheus* |
| 115 | | Pelagic thresher shark | *Alopias pelagicus* |
| 116 | | Sailfish | *Istiophorus platypterus* |
| 117 | | Skipjack tuna | *Katsuwonus pelamis* |
| 118 | | Shortfin mako shark | *Isurus oxyrinchus* |
| 119 | | Shortbill spearfish | *Tetrapturus angustirostris* |
| 120 | | Broad billed swordfish | *Xiphias gladius* |
| 121 | | Flathead pomfret | *Taractichthys asper* |
| 122 | | Dagger pomfret | *Taractichthys rubescens* |
| 123 | | Sickle pomfret | *Taractichthys steindachneri* |
| 124 | | Wahoo | *Acanthocybium solandri* |
| 125 | | Yellowfin tuna | *Thunnus albacares* |
| 126 | | Oceanic whitetip shark | *Carcharhinus longimanus* |
| 127 | | Silky shark | *Carcharhinus falciformis* |
| 128 | | Common thresher shark | *Alopias vulpinus* |
| 129 | | Escolar | *Lepidocybium flavobrunneum* |
| 130 | | Albacore | *Thunnus alalunga* |
| 131 | | Bigeye tuna | *Thunnus obesus* |
| 132 | | Black Marlin | *Makaira mazara* |
| 133 | | Bullet tuna | *Auxis rochei rochei* |
| 134 | | Pacific pomfret | *Brama japonica* |
| 135 | | Blue Shark | *Prionace glauca* |
| 136 | | Bigeye thresher shark | *Alopias superciliosus* |
| 137 | | Blue marlin | *Makaira nigricans* |
| 138 | | Dolphin fish (mahi mahi) | *Coryphaena hippurus* |
| 139 | | Brilliant pomfret | *Eumegistus illustris* |
| 140 | | Kawakawa | *Euthynnus affinis* |
| 141 | | Spotted moonfish | *Lampris guttatus* |
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| 143 | | Salmon shark | *Lamna ditropis* |
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| 158 | | Yellowfin tuna | *Thunnus albacares* |
| 159 | | Oceanic whitetip shark | *Carcharhinus longimanus* |
| 160 | | Silky shark | *Carcharhinus falciformis* |
| 161 | | Common thresher | *Alopias vulpinus* |
| 162 | | Escolar | *Lepidocybium flavobrunneum* |
| 163 | | Sand tilefish | *Malacanthus plumieri* |
| 164 | South Atlantic and Gulf of Mexico Longline | Rock sea bass | *Centropristis philadelphica* |
| 165 | | Margate | *Haemulon album* |
| 166 | | Bar jack | *Caranx ruber* |

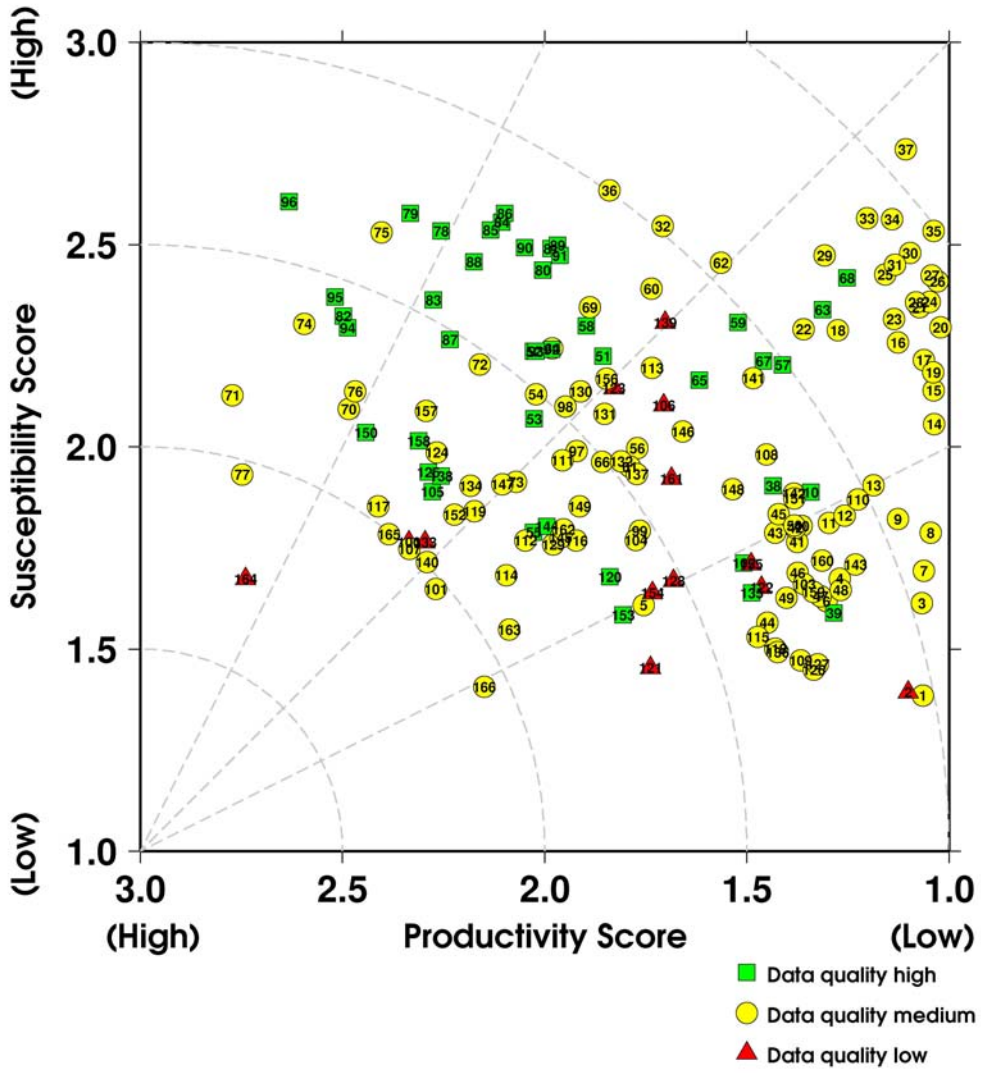


**Figure 1.** X-Y Scatter plot of productivity and susceptibility scores for 166 stocks evaluated by the VEWG, as well as the stocks associated data quality scores.

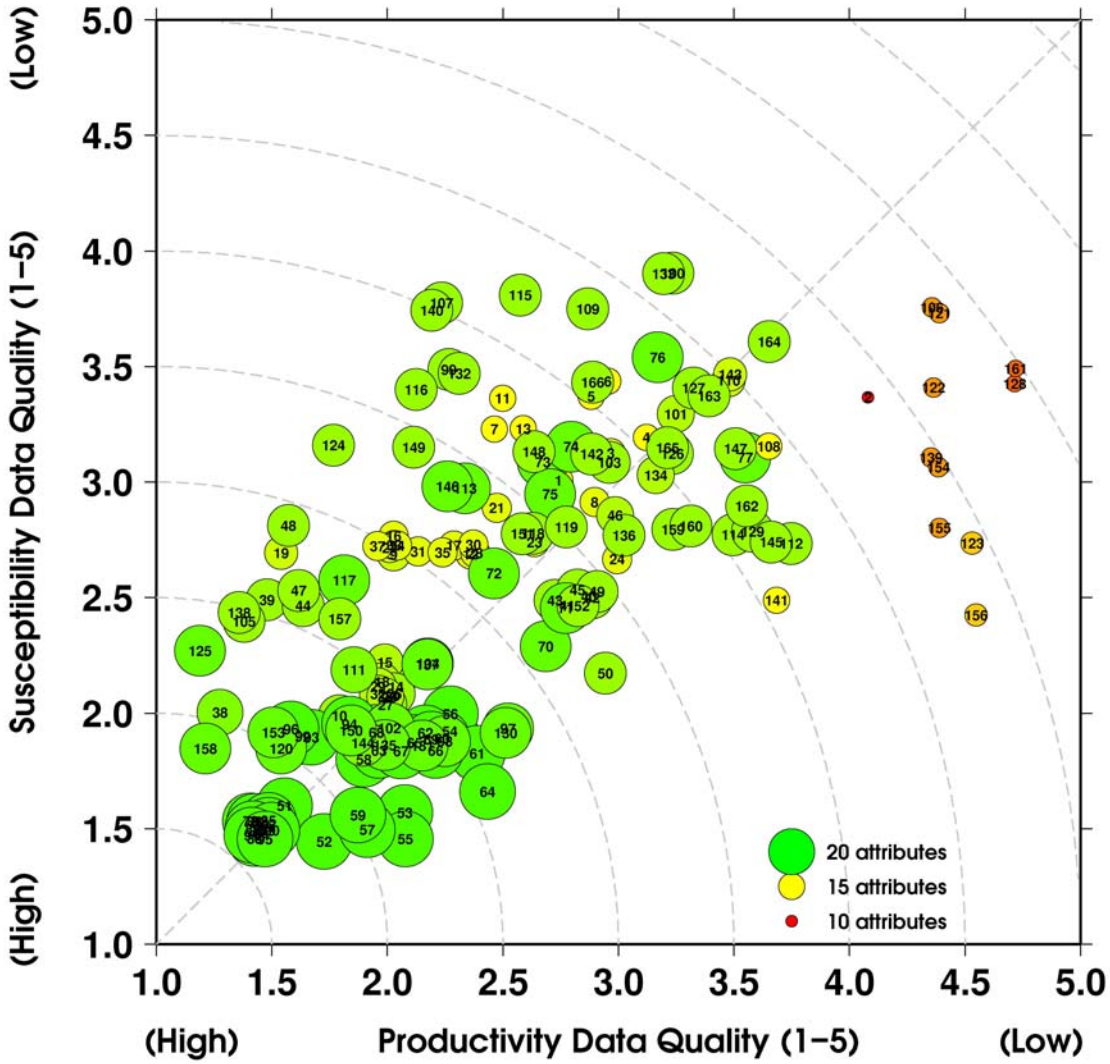


**Figure 2.** X-Y Scatter plot of productivity and susceptibility data quality scores for 166 stocks evaluated by the VEWG, noting the number of attributes used for each stock.