Appendix 3: DRAFT Alaska groundfish vulnerability analysis

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In this appendix we present preliminary results of vulnerability analysis for Alaska groundfish. Stocks from the Bering Sea/ Aleutian Islands and Gulf of Alaska regions are both covered in this draft report.

1) Overview of need and methodology
2) Results and discussion of the vulnerability analysis
3) Implications for stock classification and non-target stocks

Overview

The implementation of new National Standard guidelines published by NOAA Fisheries in 2009 requires the classification of fish stocks in a fishery management plan (FMP). Target stocks, as well as non-target stocks that are caught incidentally in large numbers, are considered to be “in the fishery”. Annual catch limits (ACLs) are required for these stocks. Fishery management councils have the option of designating a second category of less-impacted stocks, “Ecosystem Components” (EC), for which ACLs are not required. However, these stocks are monitored and councils may adopt management measures designed to limit incidental catches of EC stocks.

To aid in the classification of stocks, as well as to provide advice on the formation of stock complexes and other management actions, NOAA Fisheries convened a Vulnerability Evaluation Working Group (VEWG) in 2008. This group was tasked with developing an analytical tool for assessing the vulnerability of stocks in an FMP (the word “vulnerability” appears frequently in the National Standard guidelines). The work of the VEWG is complete and will be published soon as a NOAA Technical Memorandum and in a peer-reviewed journal. A preliminary report and other supporting materials that explain the group’s work in detail can be found at www.nmfs.noaa.gov/msa2007/vulnerability.htm. Here, a brief review of the analysis is provided to aid interpretation of the results for Alaska groundfish.

The analysis developed by the VEWG is based on previous work in Australia and elsewhere. It compares two main features of a fish stock that together influence its vulnerability to fishing: productivity, which determines a population’s natural capacity for growth and its resilience to fishery impacts; and susceptibility, which indicates how severe those fishery impacts are likely to be for the population. Productivity and susceptibility are evaluated by scoring a number of related attributes. For productivity, these are mainly life-history traits such as natural mortality rate and age at maturity; susceptibility attributes include spatial overlap between the stock and the fishery, stock status, etc. The table below lists all attributes evaluated in the productivity-susceptibility analysis (PSA):

productivity attributes	susceptibility attributes
r	management strategy
maximum age	areal overlap
maximum size	geographic concentration
growth rate (*k*)	vertical overlap
natural mortality	fishing rate relative to M
measured fecundity	biomass of spawners (SSB) or other proxies
breeding strategy	seasonal migrations
recruitment pattern	schooling/aggregation and other behaviors
age at maturity	gear selectivity
mean trophic level	survival after capture and release
	desirability/value of the fishery
	fishery impact to habitat

Each attribute is scored with a 1, 2, or 3, indicating low, medium, and high values, respectively. Each attribute score is then weighted according to the analyst's interpretation of the relevance of each attribute. In the Alaska groundfish PSA, all attributes were weighted equally with the exception of recruitment pattern, which was deemed to have an inconsistent relationship to productivity and received a weight half that of the other attributes. The weighted attribute scores are used to calculate mean scores for productivity and susceptibility that are used in two separate ways:

1) The scores are depicted graphically in a scatter plot, with productivity on the x-axis and susceptibility on the y-axis. This provides a strong visual appreciation of differences among stocks. In addition, the x-axis is reversed (i.e. it starts at 3 and ends at 1), so that the area of the plot close to the origin (which is at 3,1) corresponds to high-productivity, low-susceptibility stocks. Such stocks are considered to have low vulnerability. The further a stock is from the origin, the more vulnerable to fishing it is likely to be.
2) Following on (1), the Euclidean, or straight-line, distance from the origin to the stock's datapoint is calculated and used as a measure of the stock's overall vulnerability. The distance is calculated as:

$$\sqrt{(P-3)^2 + (S-1)^2}$$

where P = productivity and S = susceptibility.

Each attribute score is also evaluated for the quality of the data used to determine the score. Data quality scores range from 1 to 5 as follows:

1: (Best data) Information is based on established and substantial data
2: (Adequate Data) Information with limited coverage and corroboration
3: (Limited Data) Limited confidence; may be based on similar taxa
4: (Very Limited Data) Expert opinion or based on general literature review
5: (No Data) No information to base score on

The data quality scores are reported in tables and the average data quality scores are depicted graphically (green = data quality <2; yellow = data quality >2 but <3; red = data quality >3).

A separate PSA was conducted for each region, Gulf of Alaska (GOA) and Bering Sea/ Aleutian Islands (BSAI). Stock assessment authors were asked to provide attribute scores for the stocks they are responsible for, and the analyst (Ormseth) used those scores to produce the PSA. One of the difficulties of producing a PSA is that the susceptibility of a stock depends on the gear type under consideration (e.g. a skate is more susceptible to a bottom longline than a midwater trawl). In this analysis, the attributes were scored according to the fishery and gear type that would have the most impact on the stock- e.g. squids were evaluated relative to midwater trawl gear, where most of the incidental catch occurs. While it may seem that this biases the analysis towards overestimating impacts- because you may have a fishery with a lot of overlap with a stock where the catch of that stock is fairly low- in practice this type of situation is "corrected" within the susceptibility analysis. If the incidental catch is low in a particular fishery and gear type, there will be some reason for it (e.g. low selectivity) that will be captured in the analysis. Similarly, if catch is high in that particular fishery and gear type, but the fishery itself is small, this will be captured in such attributes as the fishing rate relative to *M*.

Results and Discussion

The results of the GOA analysis are presented in Table 1 and Figure 1; the results of the BSAI analysis are presented in Table 2 and Figure 2. The results indicate the following:

1) Productivity varies widely among stocks in both regions, but susceptibility is constrained to moderate values. This is especially true for the BSAI. This is probably due in large part to the fact that all stocks evaluated in each PSA are included in that region's FMP (with the exception of

giant grenadier; see below). Thus, a common level of susceptibility among the stocks makes sense.

2) The main target stocks (e.g. pollock and Pacific cod) in each region have the highest susceptibility scores.
3) Data quality is highest for target stocks and lowest for non-target stocks. There is no relationship between data quality and vulnerability.
4) Vulnerability does not appear to depend on whether a stock is targeted or not. In Tables 1 & 2, stocks are listed in order of increasing vulnerability. The target stocks are distributed among the intermediate vulnerability scores in each region, with non-target stocks displaying the lowest and highest scores. This is likely because, although target stocks tend to have higher susceptibility they also have higher productivity.
5) There are no clear divisions among stocks in the PSA, i.e. there appears to be a continuum of vulnerability rather than distinct levels of vulnerability.
6) High vulnerability scores can be a result of low productivity, high susceptibility, or both. For example, in the GOA, pollock and Dover sole have similar vulnerability scores (1.44 and 1.34, respectively) despite the lower productivity of Dover sole.

Implications for stock classification and nontarget management

Ecosystem components

There are no clear divisions among the stocks in their vulnerability scores, and the working group that developed the methodology did not provide any guidance regarding how the vulnerability score of a stock corresponds to the appropriate management measures for that stock (this was done on purpose due to the difficulty of making divisions that would be broadly applicable in different regions). However, considering the vulnerability scores relative to each other and particularly to the scores of target stocks provides some insight into how stocks should be classified.

In the BSAI (Figure 2), squid have the lowest vulnerability (0.84) and they have the most distinct vulnerability score. In addition, vulnerability scores for target stocks begin at 1.39 (yellowfin sole). The analyses conducted by the VEWG also suggested that target stocks and nontarget stocks commonly believed to be conservation concerns (e.g. BSAI skates) tended to have vulnerability scores greater than 1. Thus, the PSA for this region suggests that squid may be a candidate for EC classification.

This conclusion is supported by the results for the GOA (Figure 1), where squid, capelin, and eulachon form a somewhat distinct, high-productivity group. Eulachon have the highest susceptibility score of this group, as they are the only member of the forage fish category that is regularly caught in the groundfish fisheries. The PSA results suggest that the current management measures used for capelin and eulachon as part of the forage fish classification (i.e. no ACLs) may also be appropriate for squid. Octopus have a vulnerability score almost equivalent to eulachon and so may be considered for EC classification. However, their lower productivity separates them from the squid/forage fish group. This separation is even more pronounced in the BSAI.

In summary, the PSA results demonstrate that squid and forage fishes have relatively low vulnerability to commercial fishing and may be candidates for an EC classification. Octopus also have low vulnerability scores. While some sculpin species have relatively low scores (though still greater than 1), other members of that group have high scores. As a result, sculpins should remain “in the fishery”. Skates and sharks have high vulnerability scores and require ACLs.

Giant grenadier

Grenadiers are not listed in the current FMPs but were included in the analysis due to potential conservation concerns. The PSA results suggest that grenadiers should be included as stocks “in the fishery” in the FMPs for both regions. In the GOA, the vulnerability score for giant grenadier is between Pacific cod and Pacific ocean perch (Table 1). In the BSAI, giant grenadier is between Pacific cod and pollock (Table 2). Thus, management measures (ACLs) appropriate for these target species should also be applied to grenadiers.

A suggestion for management of EC stocks

The National Standard guidelines do not specify what management measures should be applied to EC stocks. While protections are not mandated for EC stocks, neither are they prohibited. In addition, councils are encouraged to apply measures that are consistent with National Standard 9, which deals with the reduction of bycatch. Thus the NPFMC has wide latitude to apply conservation measures to EC stocks that it feels are appropriate, and I suggest the following measures for consideration for EC stocks:

1) Similar to the current practice for forage fishes, directed fishing would be prohibited.
2) Maximum retention allowances (MRAs) would be applied to all EC stocks, but the MRA level could vary among individual stocks.
3) Because they have no ACLs, the potential exists for incidental catches of EC stocks to become excessively high, even if current conditions indicate low vulnerability. For example, catches of squid might increase if the pollock population grows and pollock harvests increase. To prevent this from happening, the council could implement a strict catch monitoring system with consequences if catches exceed a threshold. This threshold (the “allowable incidental catch”, AIC) would be based on current methods used to determine overfishing level (OFL) for either Tier 5 or Tier 6 species- i.e. it would be based on either survey biomass or historical catch. If the AIC for a stock were to be exceeded more than once every three years there would be a mandatory review of the stock’s status by the Plan Teams and SSC, with the possibility of reclassification of that stock as “in the fishery” if warranted. This approach would ensure that the EC classification does not result in uncontrolled incidental catches of EC stocks.

Implications for stock complexes

While it is not the focus of this report, the PSAs presented here are also useful for considering how and whether stocks are formed into stock complexes. The National Standard guidelines suggest, among other requirements, that stocks in a complex should have similar vulnerability scores. The results for Alaska groundfish demonstrate that the Other Species complex is an inappropriate grouping (members of the complex are on opposite ends of the vulnerability spectrum) and support the NPFMC’s move towards breaking the Other Species complex into individual species groups. In addition, there is considerable variability in vulnerability among the sculpins. The NPFMC might consider breaking sculpins into two groups or basing the management of sculpins on the most vulnerable species.

Table 1. Results of the productivity/ susceptibility analysis for the Gulf of Alaska region. Fish stocks are organized in order of increasing vulnerability score. Bold italics indicate target species.

ID #	stock name	productivity	susceptibility	vulnerability	data quality		
					P	S	average
1	capelin	2.75	1.50	0.56	2.58	3.27	2.93
2	squid	2.63	1.71	0.81	2.79	3.55	3.17
3	eulachon	2.69	2.00	1.05	2.68	2.36	2.52
4	octopus	2.14	1.63	1.06	2.89	3.82	3.36
5	great sculpin	1.88	1.71	1.33	3.11	3.18	3.14
6	plain sculpin	1.88	1.71	1.33	3.11	3.18	3.14
7	***Dover sole***	***1.71***	***1.36***	***1.34***	***1.63***	***1.64***	***1.63***
8	***rex sole***	***1.87***	***1.73***	***1.35***	***1.32***	***1.64***	***1.48***
9	***pollock***	***2.29***	***2.25***	***1.44***	***1.63***	***2.36***	***2.00***
10	yellow Irish lord	1.75	1.86	1.52	3.11	3.18	3.14
11	***sablefish***	***1.76***	***2.08***	***1.64***	***1.11***	***1.27***	***1.19***
12	bigmouth sculpin	1.50	1.71	1.66	3.11	3.18	3.14
13	***Pacific cod***	***2.00***	***2.42***	***1.73***	***1.53***	***1.45***	***1.49***
14	giant grenadier	1.44	1.79	1.75	2.05	2.00	2.03
15	***Pacific ocean perch***	***1.74***	***2.29***	***1.81***	***1.47***	***1.41***	***1.44***
16	***rougheye rockfish***	***1.30***	***1.68***	***1.83***	***1.95***	***1.68***	***1.81***
17	big skate	1.33	1.90	1.89	1.63	3.00	2.32
18	salmon shark	1.19	1.75	1.96	1.95	3.73	2.84
19	longnose skate	1.22	1.90	1.99	1.53	3.27	2.40
20	spiny dogfish	1.11	1.91	2.10	1.84	3.00	2.42
21	sleeper shark	1.00	2.00	2.24	3.63	3.73	3.68

Table 2. Results of the productivity/ susceptibility analysis for the Bering Sea and Aleutian Islands region. Fish stocks are organized in order of increasing vulnerability score. Bold italics indicate target species.

ID #	stock name	productivity	susceptibility	vulnerability	data quality		
					prod	susc	average
1	squid	2.63	1.75	0.84	2.37	3.55	2.96
2	octopus	2.14	1.63	1.06	2.89	3.82	3.36
3	red Irish lord	2.13	1.71	1.13	2.47	2.91	2.69
4	Alaska plaice	2.12	1.73	1.14	1.74	1.73	1.73
5	threaded sculpin	2.14	1.83	1.20	2.37	3.36	2.87
7	longfin Irish lord	2.00	1.83	1.30	2.37	3.55	2.96
8	great sculpin	1.88	1.71	1.33	1.95	2.91	2.43
9	plain sculpin	1.88	1.71	1.33	1.95	2.91	2.43
10	great sculpin	1.88	1.71	1.33	1.95	2.91	2.43
11	warty sculpin	1.88	1.71	1.33	2.26	2.82	2.54
12	***yellowfin sole***	***1.88***	***1.82***	***1.39***	***1.74***	***1.73***	***1.73***
13	spinyhead sculpin	1.86	1.83	1.41	2.79	3.55	3.17
14	thorny sculpin	1.86	1.83	1.41	3.00	3.55	3.27
15	northern rock sole	1.88	1.91	1.44	1.74	1.73	1.73
16	arrowtooth flounder	1.73	1.73	1.46	2.05	1.73	1.89
17	yellow Irish lord	1.75	1.86	1.52	1.63	2.82	2.22
18	armorhead sculpin	1.71	1.83	1.53	2.68	3.55	3.11
19	***greenland turbot***	***1.65***	***1.75***	***1.55***	***2.42***	***2.55***	***2.48***
20	***Atka mackerel***	***2.12***	***2.33***	***1.60***	***1.95***	***2.00***	***1.97***
21	***sablefish***	***1.76***	***2.08***	***1.64***	***1.63***	***1.27***	***1.45***
22	bigmouth sculpin	1.50	1.71	1.66	1.95	2.91	2.43
23	***pollock (EBS)***	***2.00***	***2.33***	***1.67***	***1.53***	***1.27***	***1.40***
24	giant grenadier	1.47	1.79	1.72	2.00	2.00	2.00
6	***Pacific cod***	***2.00***	***2.42***	***1.73***	***1.53***	***1.45***	***1.49***
25	whitebrow skate	1.39	1.78	1.79	2.89	3.36	3.13
26	butterfly skate	1.39	1.78	1.79	2.89	3.64	3.27
27	roughshoulder skate	1.39	1.88	1.83	3.00	3.64	3.32
28	roughtail skate	1.39	1.89	1.84	2.68	3.36	3.02
29	whiteblotched skate	1.39	1.89	1.84	2.79	3.36	3.08
30	mud skate	1.39	1.89	1.84	2.79	3.36	3.08
31	commander skate	1.39	1.89	1.84	2.89	3.36	3.13
32	Bering skate	1.44	2.00	1.85	1.63	3.00	2.32
33	Alaska skate	1.42	2.00	1.87	1.26	2.18	1.72
34	big skate	1.33	1.89	1.89	1.63	3.55	2.59
35	deepsea skate	1.33	1.89	1.89	2.89	3.55	3.22
36	Aleutian skate	1.33	1.90	1.89	1.53	3.09	2.31
37	salmon shark	1.19	1.75	1.96	3.21	3.73	3.47
38	longnose skate	1.22	1.88	1.98	1.53	3.82	2.67
39	spiny dogfish	1.11	1.91	2.10	1.84	3.00	2.42
40	***rougheye rockfish (AI)***	***1.20***	***2.21***	***2.17***	***2.68***	***2.09***	***2.39***
41	sleeper shark	1.00	2.00	2.24	3.63	3.73	3.68

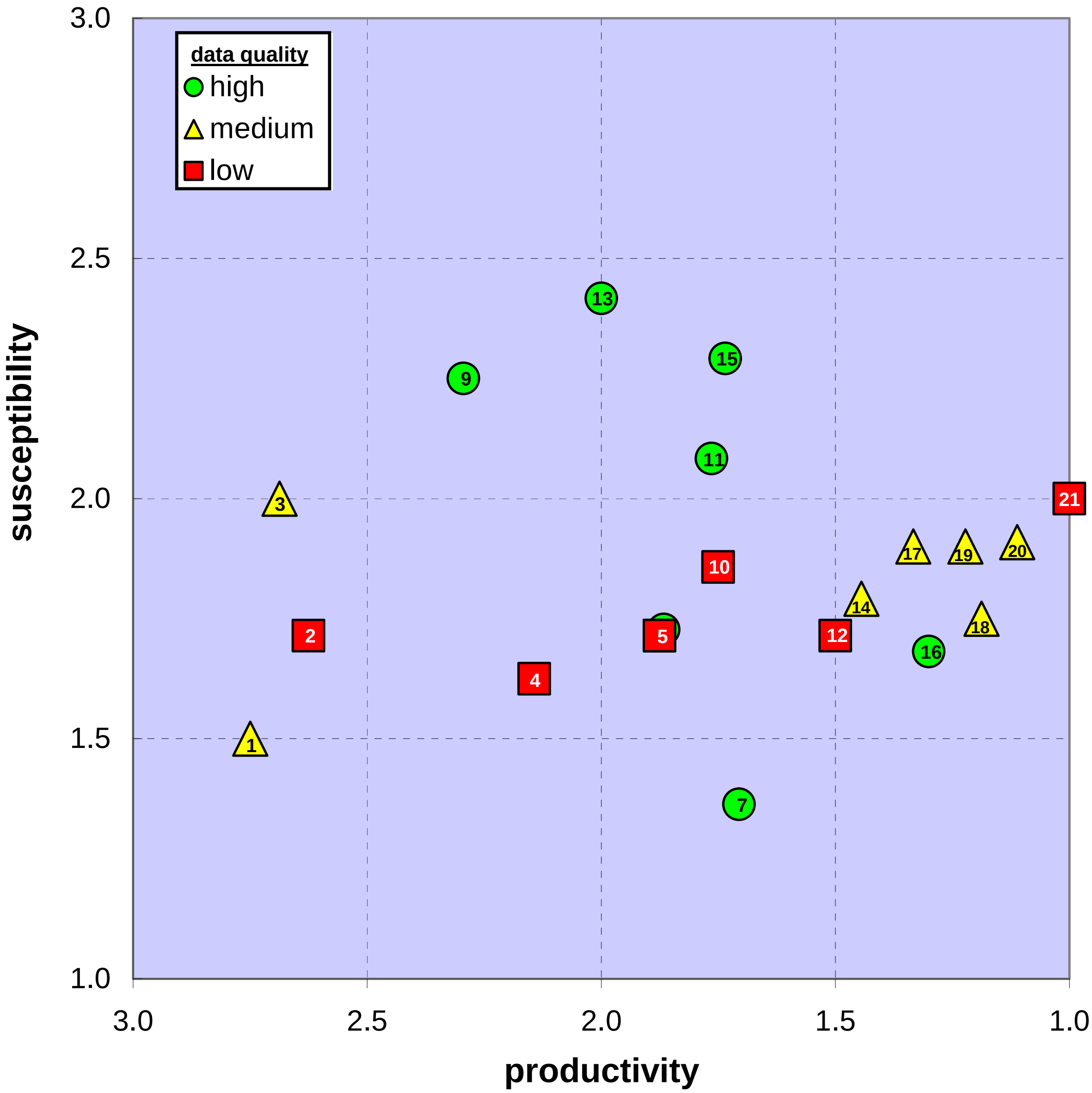

Figure 1. Results of the PSA analysis for the Gulf of Alaska region. Colors and symbol shapes indicate data quality scores. Numbers indicate stocks listed in Table 1. For clarity, not all stocks are labeled.

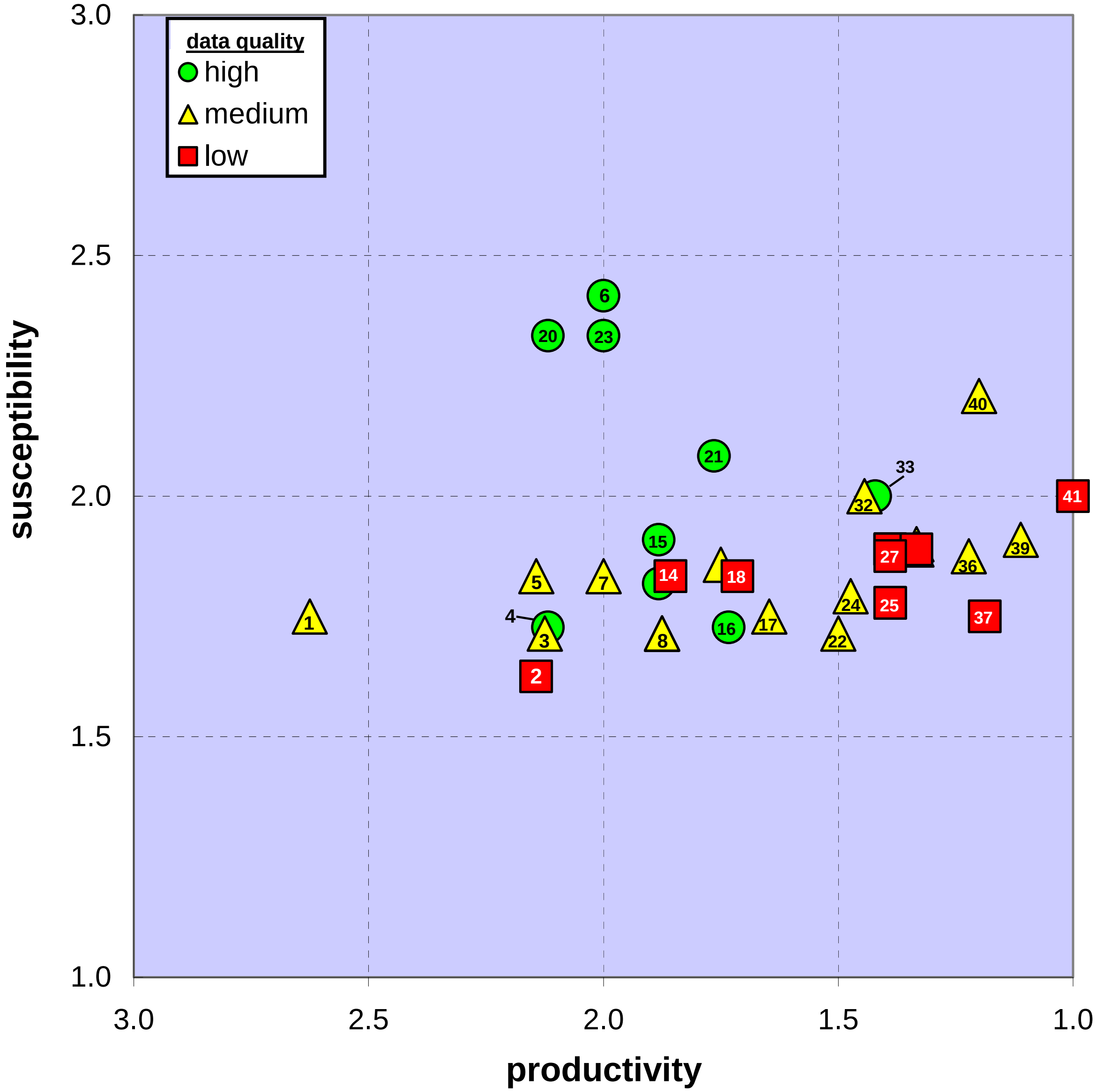

Figure 2. Results of the PSA analysis for the Bering Sea and Aleutian Islands region. Colors and symbol shapes indicate data quality scores. Numbers indicate stocks listed in Table 1. For clarity, not all stocks are labeled.