APPENDIX 5: DESCRIPTION OF HABITAT SUITABILITY INDEX (HSI) MODELING CONDUCTED BY NOS

Habitat suitability modeling (HSM) is a tool for predicting the quality or suitability of habitat for a given species based on known affinities with habitat characteristics, such as depth and substrate type. This information is combined with maps of those same habitat characteristics to produce maps of expected distributions of species and life stages. One such technique is termed habitat suitability index (HSI) modeling. A suitability index provides a probability that the habitat is suitable for the species, and hence a probability that the species will occur where that habitat occurs. If the value of the index is high in a particular location, then the chances that the species occurs there are higher than if the value of the index is low. HSI models use regression techniques to analyze data on several environmental parameters and calculate an index of species occurrence. Since this methodology has potential for use in designating EFH and HAPC, we review it briefly here. It is described in more detail in various scientific publications (see for example Christensen *et al*. 1997, Clark *et al*. 1999, Coyne and Christensen 1997, Rubec *et al*. 1998, Rubec *et al*. 1999, Monaco and Christensen 1997 and Brown *et al*. 2000).

Suitability index (SI) values are generated for important habitat characteristics. For example, one can calculate the likelihood of a species being present given a certain depth and substrate type. In situations where trawl or other survey data are available, these can be used to generate SI values based on trends in species abundance with the habitat characteristic under consideration. Figure A3.1 shows data that indicate the change in the abundance of juvenile bocaccio with depth. The curved line is a mathematical model that has been used to represent the data points shown on the graph[1]. Table A3.1 shows how the model is used to calculate HSI values for different depths.

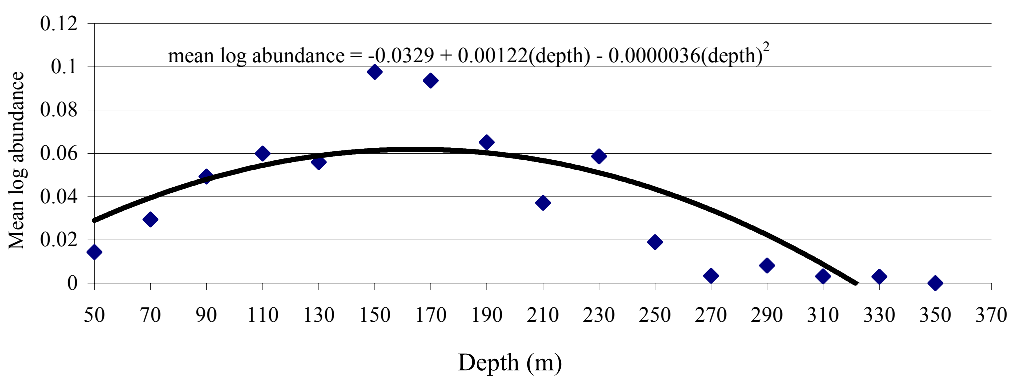

Figure A6.1 Polynomial regression curve fit with mean log abundance by categorical bathymetric class for juvenile bocaccio (graph provided by NOS).

[1] We note that the model shown in Figure A3.1 is not a very good fit to the data, particularly at the margins of the depth distribution.

Table A6.1 Example data matrix for calculating bathymetry SI values for juvenile bocaccio taken in NMFS trawl samples (Rubec *et al*., 1999).

Depth Class (m)	Effort (# of samples)	Mean log abundance	Predicted mean log abundance (x)	HSI (x/xmax)*10
50-69	219	.014	.019	3
70-89	361	.029	.035	5
90-109	447	.049	.048	7
110-129	489	.060	.058	8
130-149	398	.056	.065	9
150-169	252	.100	.069	10
170-189	200	.094	.070	10
190-209	213	.065	.069	10
210-229	182	.037	.064	9
230-249	98	.059	.057	8
250-269	92	.019	.047	7
270-289	89	.003	.034	5
290-309	74	.008	.018	3
310-329	98	.003	0	0
330-349	52	0	0	0

In data-poor situations, a literature review of the available information has been used to develop the HSI values. Each reference is used to provide a score indicating whether a species is present or absent within a given range for an environmental parameter. Presence/absence scores (1=present, 0=absent) are then summed for each range, and scaled by dividing by the maximum score. The resulting SI values range from 0 to 1, with 1 indicating highest suitability. For example, if authors of 5 out of 10 research studies said a certain fish was found between 50 and 100 meters, the SI score for that depth range would be 0.5

Table A6.2 illustrates how SI scores have been derived for depth as an example.

Table A6.2 Species occurrence table for presence of a species at different depths

	Depth category (m)				
Author	0-50	51-100	101-300	301-600	801-1000
Literature Reference 1	0	1	1	1	0
Literature Reference 2	0	1	1	0	0
Literature Reference 3	1	1	0	0	0
Literature Reference 4	1	1	0	0	0
Literature Reference 5	1	1	0	0	0
Literature Reference 6	0	1	1	0	0
Literature Reference 7	1	1	1	1	0
Total	4	7	4	2	0
SI Value	0.57	1.00	0.57	0.29	0.00

Species occurrence tables (also called matrices) are developed for each of the habitat characteristics in the model. Once SI values have been calculated for several habitat characteristics, by one or other of the methods described above, the values that relate to the conditions in each GIS map grid reference (i.e. based on maps of each of the habitat characteristics), are averaged (geometric mean) and these averages are values are mapped. The resulting maps show the expected distribution of each species and life stage included in the analysis (Figure A3.2).

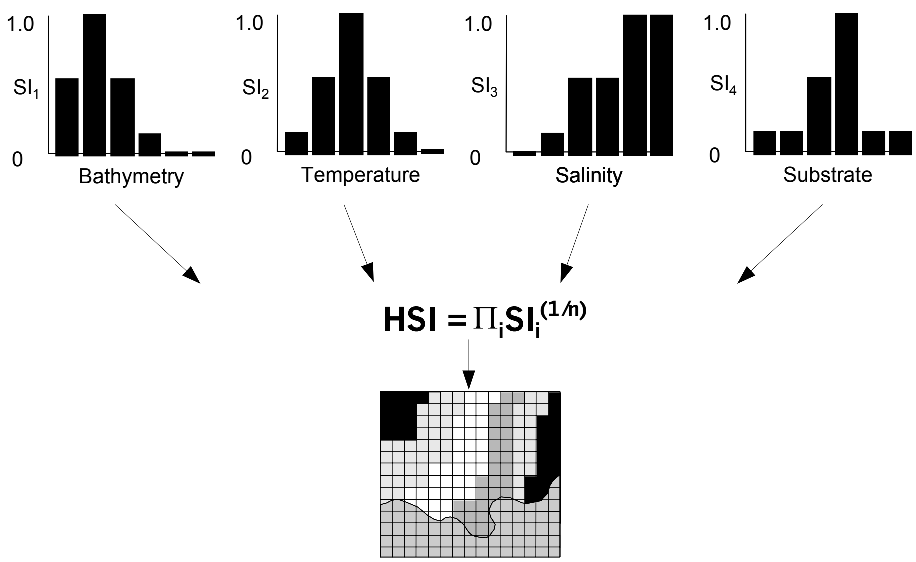

Figure A6.2 Mapping habitat suitability using SI scores (darker shades = higher suitability)

Currently, SI scores have been developed by NOS for 18 adult groundfish species from analyses of data from three central California marine sanctuaries. Depth and bottom substrate type were used as the habitat characteristics to examine habitat quality for benthic species. Mean sea surface temperature and depth were used to model pelagic species distribution. The substrate type consisted of two categories- hard and soft, although there are plans to further classify these to include, sand, mud, cobble, gravel, rock and boulders.

Extrapolation of SI scores spatially ideally requires that the following conditions are met:

(1) independence between the factors that are used to construct the SI scores;
(2) there is sufficient variability in the studies so as to reflect conditions prevailing across the entire fisheries management area.

In addition, if literature studies are used, the studies should be carefully screened to ensure that differences in results between studies are genuinely related to habitat suitability, and are not confounded by differing methodologies, historical changes in habitat suitability (e.g. through pollution), changes in population size or density (e.g. through fishing pressure), or geographical location. Also, the references should contain no repetitions, for example through literature reviews or other citations of previous research findings

It seems unlikely that all these conditions have been fully met in the HSI approach. For example, there is strong evidence to suggest that there is important interaction between the habitat factors used to construct the HSI scores. In addition, the use of the geometric mean to calculate the overall HSI may give unintended, or inaccurate results when one of the component indices is very low. However, some model validation has been conducted, with favorable results. For example, comparing predicted suitability scores with independent trawl survey data or recreational catch data indicates a satisfactory model fit in most cases.