Assessing the Effects of Habitat Alteration on Bay Scallop, *Argopecten irradians*, Populations

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Background

The U.S. EPA has implemented a framework for ecological effects research on aquatic stressors, with the ultimate goal of developing approaches for protecting and restoring the ecological integrity of aquatic ecosystems from the impacts of multiple stressors, including habitat alteration. Habitat alteration is a serious problem: there is not much national consistency in protection of most habitats, EPA Regions and State managers lack tools to regulate habitat alteration, and habitat alterations are difficult to reverse. Therefore, there is a need to improve assessment methodologies, diagnostic capabilities, and ecological criteria development for managers to be able to protect habitats and to restore habitats to meet designated uses.

We are developing habitat stressor-response models for the bay scallop, *Argopecten irradians*, an economically and societally important marine species. *Argopecten irradians* commonly inhabit shallow bays and coves along the Atlantic coast of the United States. Bay scallops can be considered the closest species to an obligate submerged aquatic vegetation (SAV) resident (Laney 1997), as juveniles primarily utilize SAV blades for settlement substrates. Thus, SAV habitat is essential as individuals transition from planktonic larvae to epibenthic adults. Because this species has a short life span of 26 to 30 months, it is vulnerable to habitat alteration that causes loss of critical SAV habitat for juveniles. The effects of habitat alteration on bay scallop populations will be quantitatively evaluated using a three-tiered modeling effort: a Habitat Suitability Index (HSI), a matrix population model, and a systems model.

NHEERL Ecological Effects Research

The Aquatic Stressors Framework:

- Describes research to understand the relationships between key stressors of concern for EPA's Office of Water and responses of populations of fish, shellfish, and aquatic-dependent wildlife

Goals:

- Develop methods for predicting biological effects of habitat alteration
- Determine how populations of fish, shellfish, and aquatic dependent wildlife respond to habitat alteration

The Wildlife Research Strategy:

- Approach for integrating NHEERL's ecological effects research focusing on risks to populations of wildlife and aquatic species
- The first step involves a spatial and temporal characterization of habitat suitability that may have an impact on the assessment population (**Fig. 1**). The second step uses stressor-response relationships to translate stressor information into effects on key demographic rates, which drive the population models in the third step. These population measures are then inserted back into the landscape to determine habitat-specific population dynamics that would provide estimated risks of habitat changes.

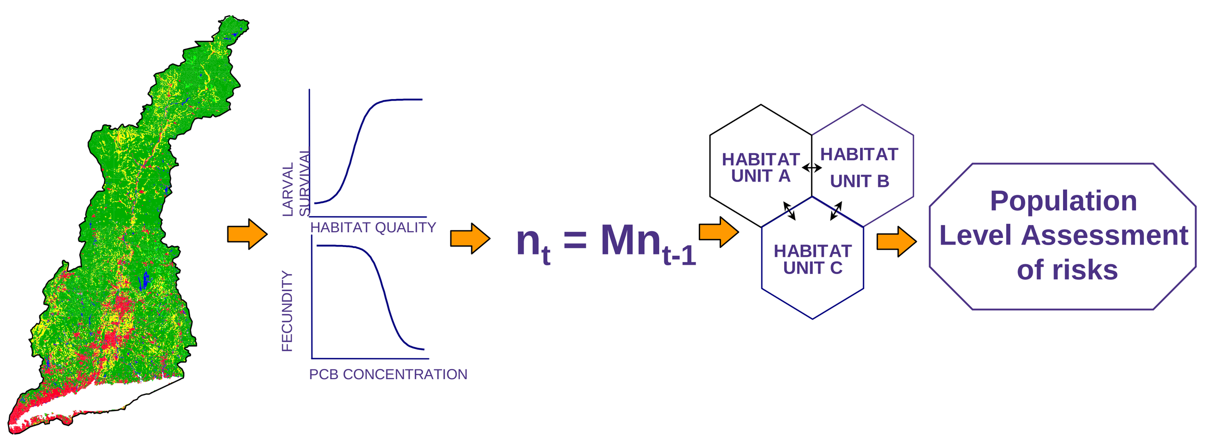

Figure 1. Conceptual approach to wildlife risk assessment.

Questions Being Addressed:

1) How can we use the knowledge of scallop-habitat relationships to guide criteria development and inform/evaluate restoration efforts?

2) Or put another way, if the Designated Use is self-sustaining populations, then what attributes of habitat must be maintained or restored?

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I. Habitat Suitability Index

- The HSI combines the interactions of key environmental variables into an index that predicts the ability of a habitat to support a particular species
- HSI results will be used to modify the population model, making it a function of the habitat. For example, the effects of different life-support functions of the vegetated habitat (**Fig. 2**) on bay scallop survival probability can be determined
- The species' habitat preference can be presented as a response to differences in each habitat variable. This response can be represented as a curve, with values of the habitat attribute on the x-axis and the species' use values on the y-axis (Slauson 1988)

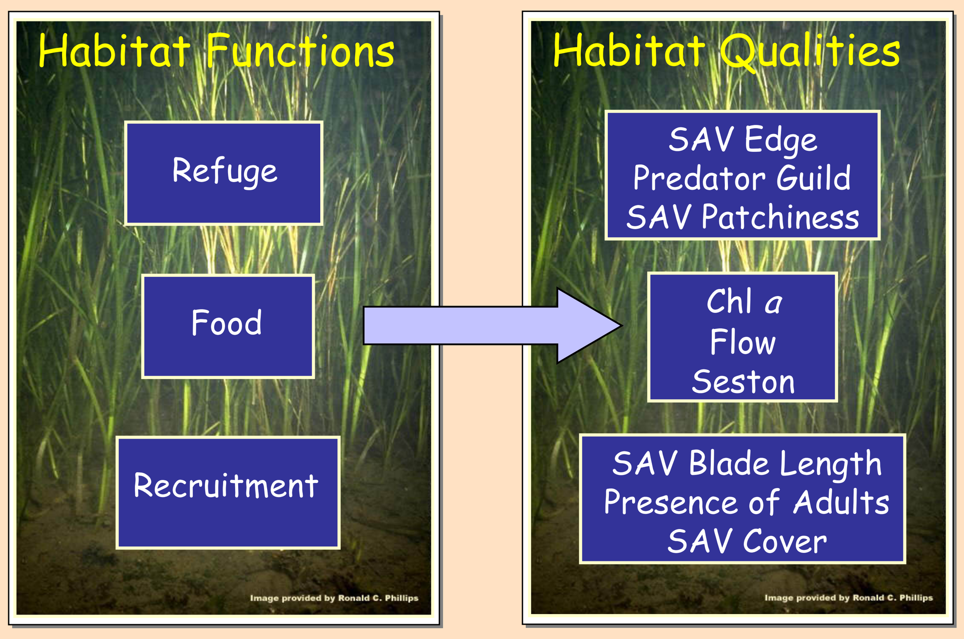

Figure 2. Illustration of the relationship between the life support functions or life requisites that a habitat may provide (on the left) and a series of measurable, biologically defined variables (on the right) that can be used to characterize the habitat functions for a given species.

II. Stage-Based Population Model

- The life history of *Argopecten irradians* was divided into five classes to capture the developmental stages of the bay scallop (**Table 1**)
- Rate coefficients were used to describe transitions between stage classes (**Fig. 3**). Transition rates in the scallop model were assumed to be constant with respect to time, density, and general environmental conditions for the base model, but can be varied as a function of habitat loss in future models
- The finite population growth rate (γ) calculated for each habitat alteration scenario can then be used as a measure of population level effects resulting from habitat loss

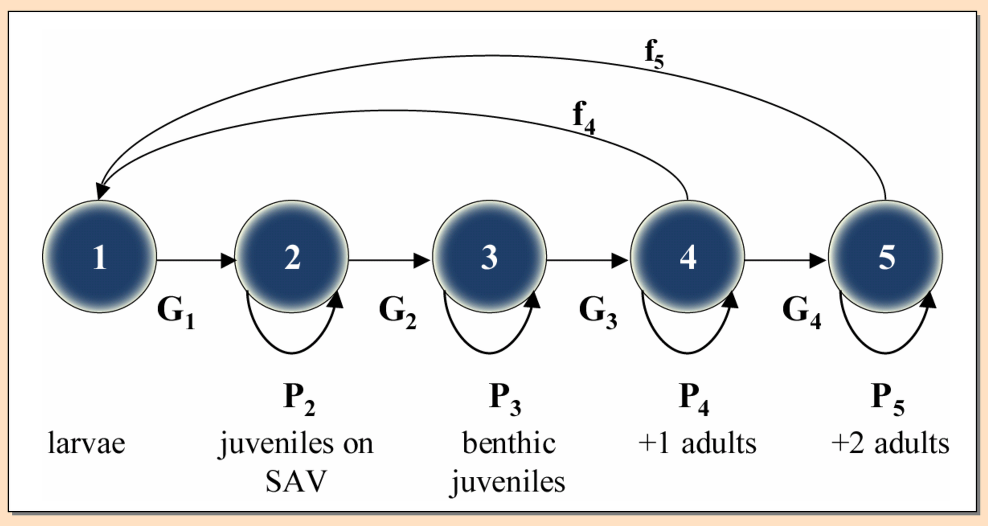

Figure 3. Life cycle representation of the stage-based population model for *Argopecten irradians* with a 2-week time step. G_i is the probability of an individual surviving to the next stage class during a time step; P_i is the probability of an individual surviving and remaining in that stage class during a time step; f_i is the reproductive output of an individual in that stage class during a time step.

Table 1. *Argopecten irradians* **Life History**

	Stage	Size	Age	Survivorship	Fecundity
1	larvae	0.175 mm	0.25-0.5 mo	0.001%	0
2	juveniles on SAV	<10-30 mm	0.5-2.5 mo	20%	0
3	benthic juveniles	15-55 mm	0.5-12 mo	20-50%	0
4	+1 adults	55-90 mm	12-24 mo	10-20%	12.6×10^6 - 18.6×10^6
5	+2 adults	55-90 mm	24-30 mo	0%	6.9×10^6 - 10.2×10^6

Literature Cited

Laney, R.W. 1997. The relationship of submerged aquatic vegetation (SAV) ecological value to species managed by the Atlantic States Marine Fisheries Commission (ASMFC): Summary for the ASMFC SAV subcommittee. In: Atlantic Coastal Submerged Aquatic Vegetation: A review of its ecological role, anthropogenic impacts, state regulation, and value to Atlantic coastal fish stocks. C.D. Stephan and T.E. Bigford, eds. pp. 13-37.

Slauson , W.L. 1988. Constructing suitability curves from data. In: K. Bovee and J.R. Zuboy, eds., Proceedings of a Workshop on the Development and Evaluation of Habitat Suitability Criteria. U.S. Fish and Wildlife Service,Ft. Collins, CO. pp. 225-258.

III. Systems Perspective of Scallop Habitat

- Links habitat alteration effects on the scallop population with ecosystem-scale environmental attributes (**Fig. 4**)
- Note also that the model includes ecosystem linkages at all trophic levels and all habitat types, and evaluates scallop survival in relation to climate, watershed land use, water quality, refugia, food availability and predation
- Model will be run both over time and in spatial context

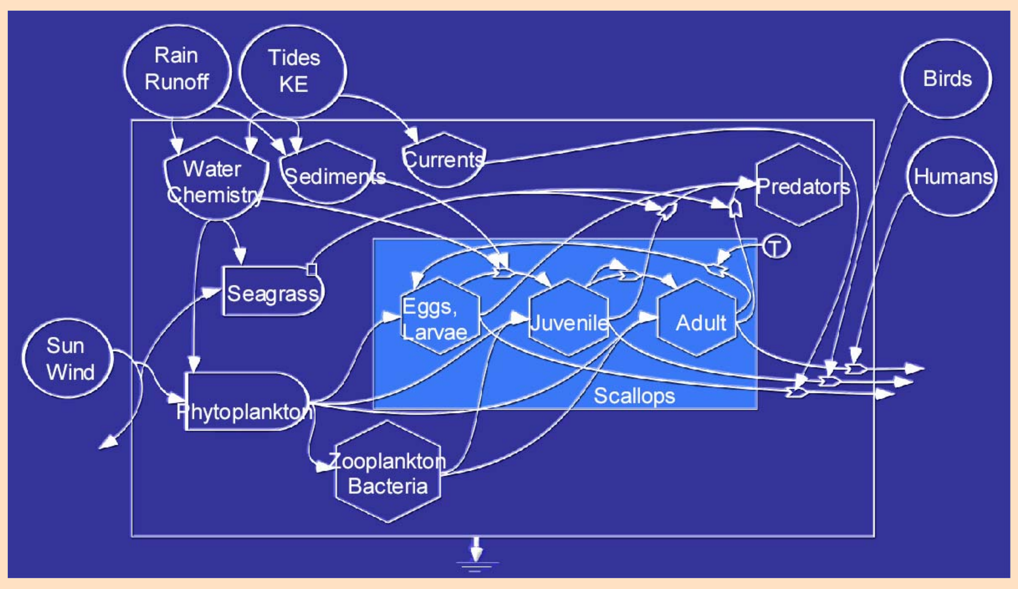

Figure 4. This model demonstrates the complex pathways and potential indirect effects of population response to multiple stressors, and shows how different habitat components can mediate this response.

Application of the Models

- The three-tiered modeling approach will allow us to represent combined interactions of all scallop-habitat relationships, link habitat alteration with demographic attributes of the population, and combine habitat alteration effects on populations with ecosystem-scale environmental attributes (**Fig. 5**)
- Ultimately, habitat criteria can be based on numeric cut-offs from relationships between stressor (habitat alteration) and response (fish, shellfish, and wildlife) for habitat-specific designated uses (**Fig. 6**)
- Results can guide habitat criteria development and assessment of restoration efforts
- Because of links to SAV, project will dovetail with AED's Aquatic Stressors Nutrients Program
- Compliments SAV-species research at GED, MED and WED under Aquatic Stressors Altered Habitat

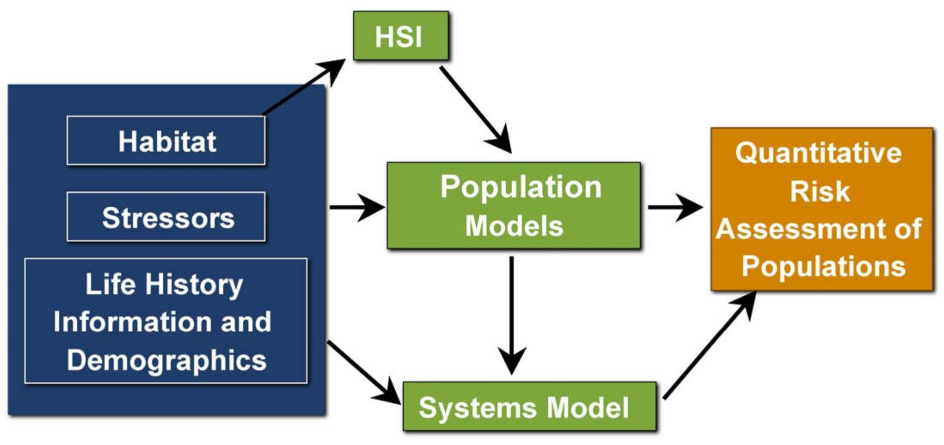

Figure 5. Three-tired modeling approach that leads to quantitative risk assessment of populations.

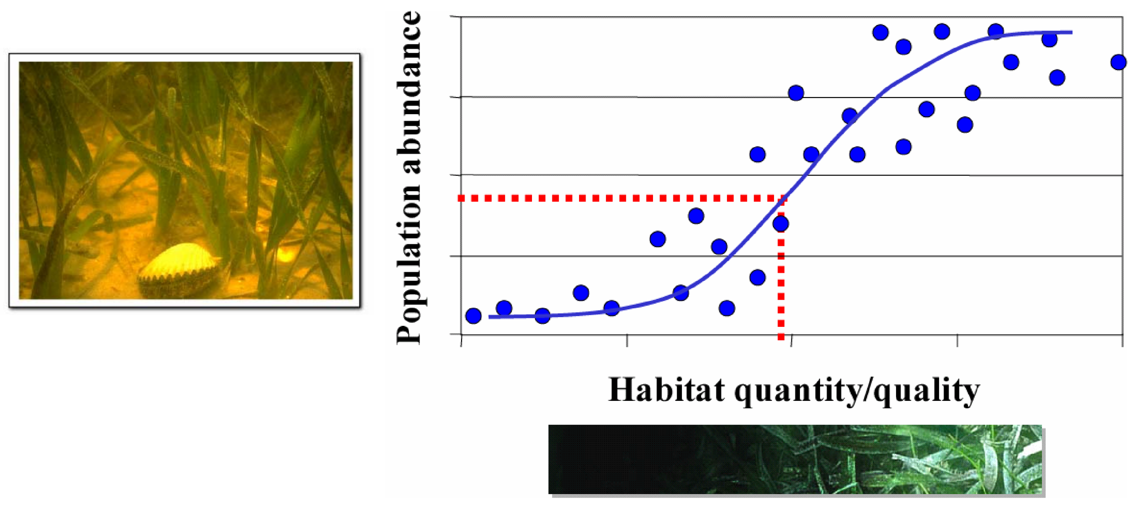

Figure 6. Conceptual example of using population and habitat data to develop a stressor-response relationship between scallops and SAV quantity or quality.

Where are We Now in the Process?

- Project is relatively new
- Preliminary HSI, population model, and systems model have been developed
- We are continuing to mine the literature and to search for all available data
- We are identifying and meeting with local, state, and academic groups to build partnerships. These include Oak Bluffs (MA) Shellfish Constable, RI Department of Environmental Management, University of Rhode Island, and Florida Marine Research Institute.
- Experiments and field surveys are planned for this summer to obtain missing data necessary for refinement of the models

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