The Swept Area Seabed Impact (SASI) Model

New England Fishery Management Council
January 27, 2010

Michelle Bachman, NEFMC staff

Outline

- How SASI works
  - Basic equations and assumptions
  - Spatial implementation
  - Features and vulnerability assessment
  - Fishing effort
- Outputs and applications
  - Simulated and realized outputs
  - Uses of model
  - Strengths and limitations

Basic SASI equation

Z = swept area seabed impact in units of contact and vulnerability adjusted area swept (km^2)

A = area swept by one unit of fishing effort

ω = susceptibility of habitat features to fishing gear

Susceptibility

$$Z = A\omega$$

Impact

Area swept

- *Z* decays over time according to the recovery rates of habitat features
- The model is indexed across all units of fishing effort (*j*) by nine fishing gear types (*i*) and a matrix of habitat types determined by combinations of five substrates (*k*), two energy environments (*l*) and 27 individual habitat features (*m*)

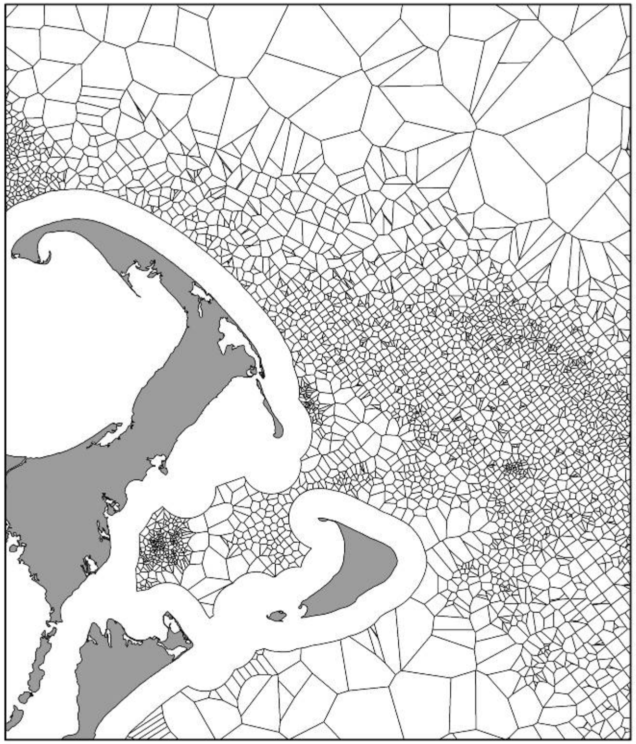
Model assumptions

- Area swept, adjusted for gear contact and feature vulnerability, is a proxy for seabed impact
- Fishing does not have significant effects on the water column
- Within a tow, fishing gear impact is constant
- Habitats are homogeneous within unstructured grid cells, and between unstructured cells with the same substrate and energy coding
- Fishing effort is additive
- Geological and biological components contribute equally to modify area swept
- Within each habitat component and for a particular substrate/energy combination, features contribute equally to modify area swept

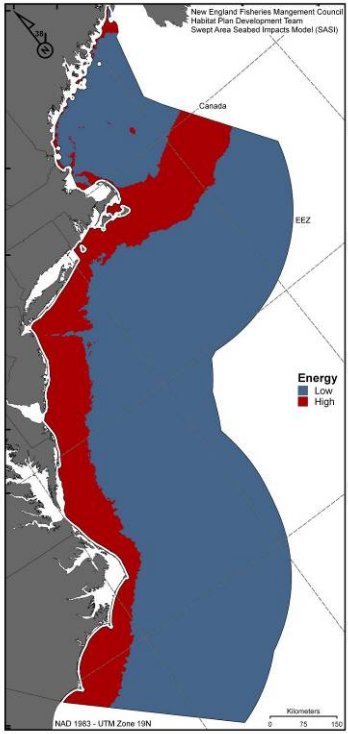
Spatial implementation

- An unstructured base grid was used to define habitats

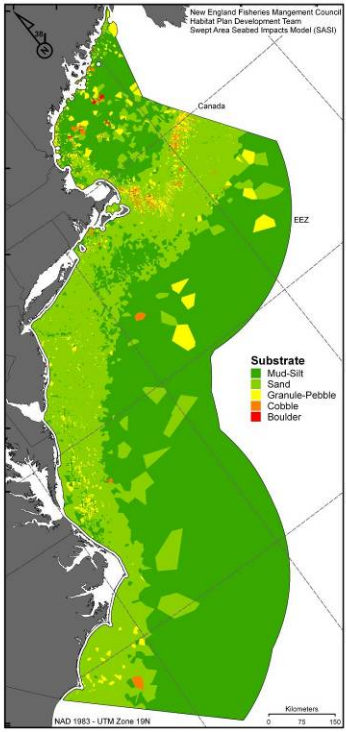
Zoom of unstructured grid:



Energy coding (n=2):



Substrate coding (n=5):



Identify habitat features

- Structural features (n=27) were identified for each habitat type as defined by a particular substrate and energy combination (n=10)

Example - low energy mud features:

Geological: *Burrows, depressions, unfeatured sediments*
Biological: *Amphipods, sea pens, hydroids, mussels, burrowing anemones*

Vulnerability assessment

- The susceptibility and recovery of each feature to each type of fishing gear was scored on a 0-3 scale

Example - mud features and trawl gear:

<table>
<tr><th colspan="8">Gear: Trawl</th></tr>
<tr><th colspan="8">Substrate: Mud</th></tr>
<tr><th>Feature</th><th>Gear effects</th><th>Literature high</th><th>Literature low</th><th>S High</th><th>S Low</th><th>R High</th><th>R Low</th></tr>
<tr><td>Amphipods, tube-dwelling</td><td>crushing</td><td>34, 113, 119, 211, 228, 292, 334, 408, 409, 599, 658</td><td>89, 80, 97, 113, 149, 320, 575</td><td>1</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>Anemones, cerianthid burrowing</td><td>breaking, crushing, dislodging, displacing</td><td>none</td><td>none</td><td>2</td><td>2</td><td>2</td><td>2</td></tr>
<tr><td>Biogenic burrows</td><td>filling, crushing</td><td>334, 408, 409</td><td>101, 313, 333, 336, 407</td><td>2</td><td>2</td><td>0</td><td>0</td></tr>
<tr><td>Biogenic depressions</td><td>filling</td><td>236, 408, 409</td><td>101, 247, 336</td><td>2</td><td>2</td><td>0</td><td>0</td></tr>
<tr><td>Corals, sea pens</td><td>breaking, crushing, dislodging, displacing</td><td>none</td><td>101, 164</td><td>2</td><td>2</td><td>2</td><td>2</td></tr>
<tr><td>Hydroids</td><td>breaking, crushing, dislodging, displacing</td><td>408, 409</td><td>368</td><td>2</td><td>2</td><td>1</td><td>1</td></tr>
<tr><td>Mollusks, epifaunal bivalve, <i>Modiolus modiolus</i></td><td>breaking, crushing, dislodging, displacing</td><td>21, 34, 368, 408, 409</td><td>89, 203, 368</td><td>2</td><td>2</td><td>3</td><td>3</td></tr>
<tr><td>Sediments, unfeatured surface</td><td>resuspension, compression, geochem</td><td>88, 92, 211, 236, 330, 334, 406, 408, 409, 599</td><td>88, 211, 247, 277, 283, 313, 320, 333, 335, 336, 338, 372, 407, 414</td><td>3</td><td>3</td><td>0</td><td>0</td></tr>
</table>

Susceptibility

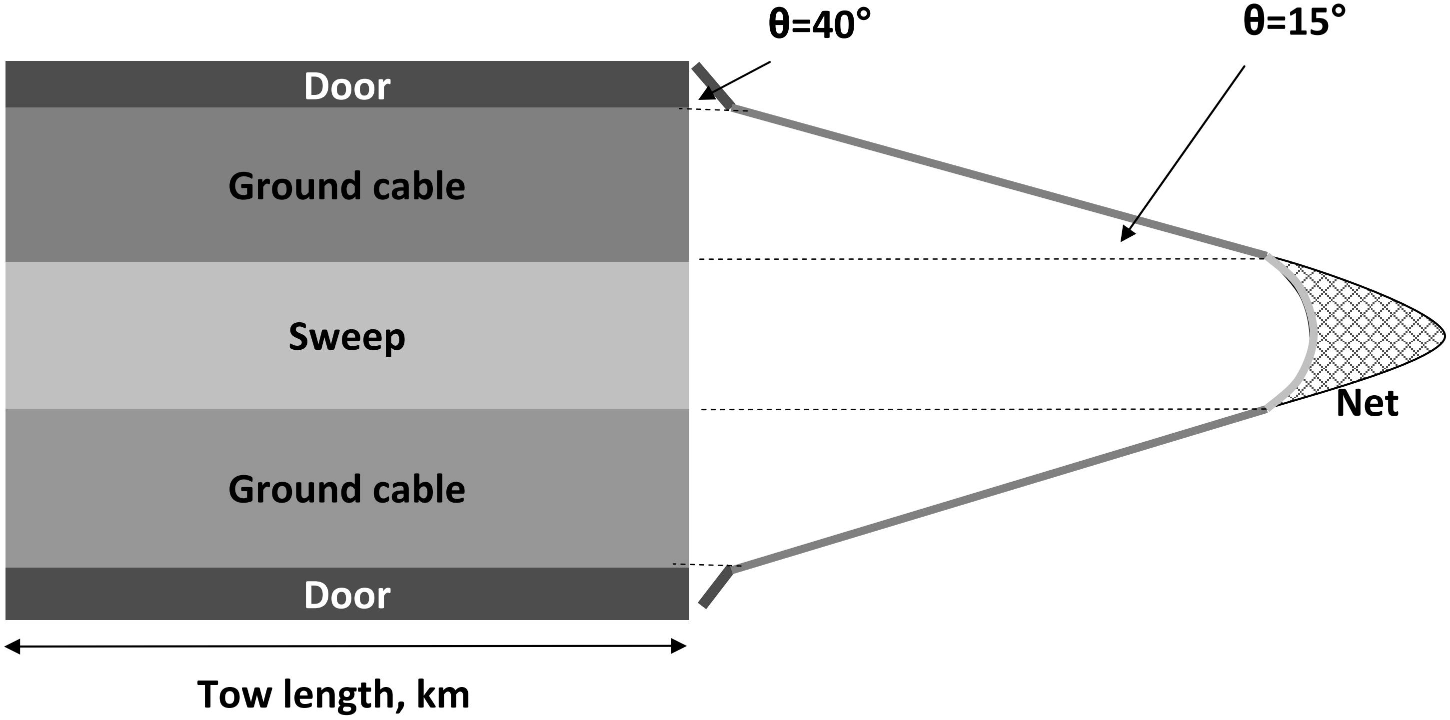
- Susceptibility of a feature was scored the same for high and low energy environments
- Also, susceptibility of a given feature was nearly always the same between substrates
- Features were generally assigned higher susceptibility scores for mobile gears vs. fixed gears
- There was little support in the literature for assigning different susceptibility scores between scallop dredges and otter trawls

Recovery

- Recovery times for geological features occasionally varied between high and low energy environments
- Recovery times for biological features were assumed independent of energy and substrate
- However, recovery sometimes varied by gear type as gear effects were assumed to vary
- Recovery times for geological features were generally shorter
- Recovery times for biological features were more variable, and generally longer

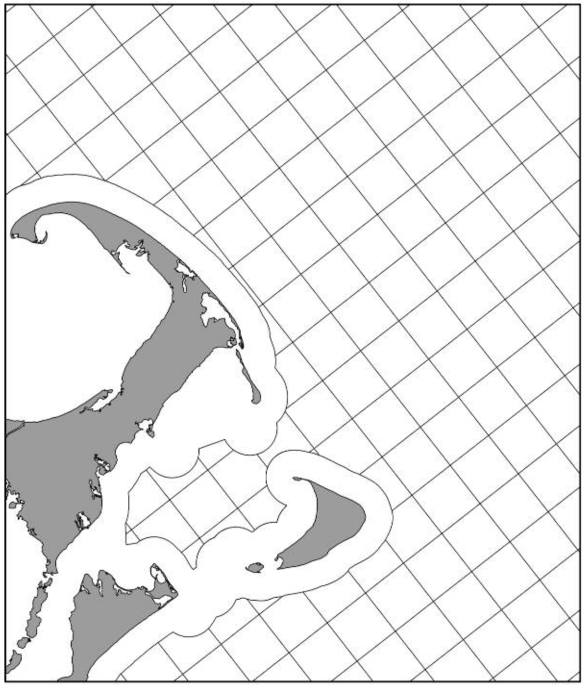
Fishing effort as area swept

- Area swept is calculated on a tow-by-tow basis and then summed across tows
- Before susceptibility scores are applied, area swept is adjusted downward according to a contact index, which is allowed to vary by gear component

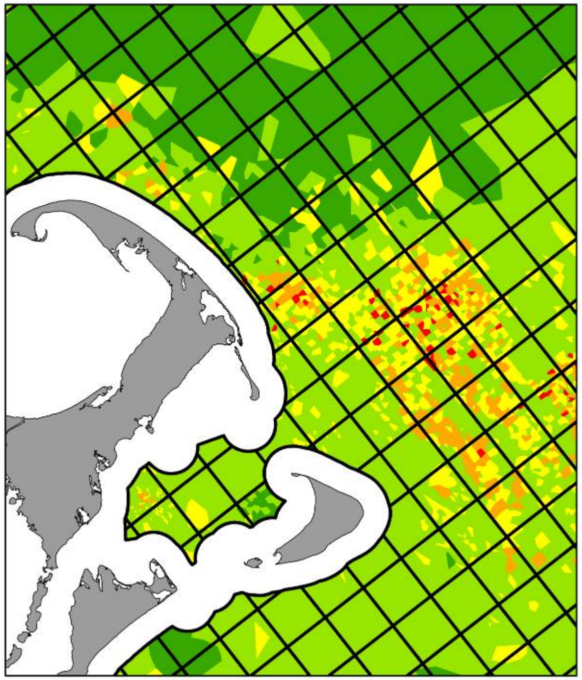


Fishing effort and substrate

Fishing effort is assigned to 100-km^2 structured grid, which can be scaled up or down if needed:

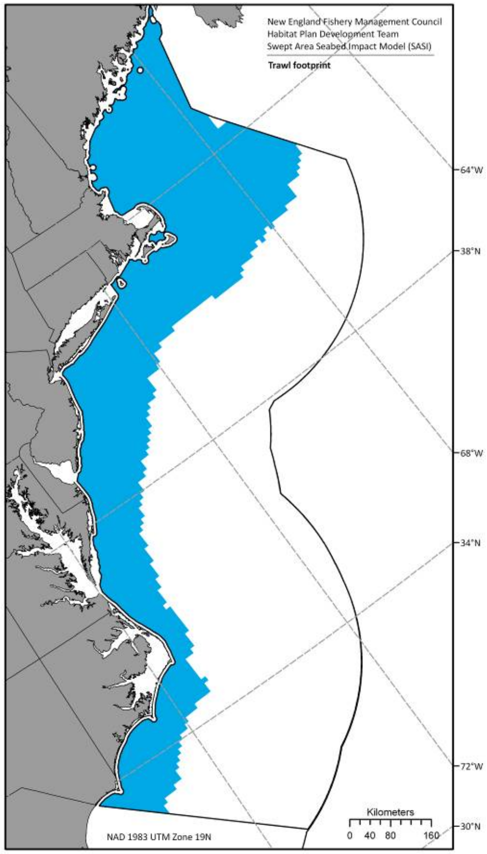


The overlay of structured and unstructured grids retains underlying substrate and energy information, and thus feature scores:



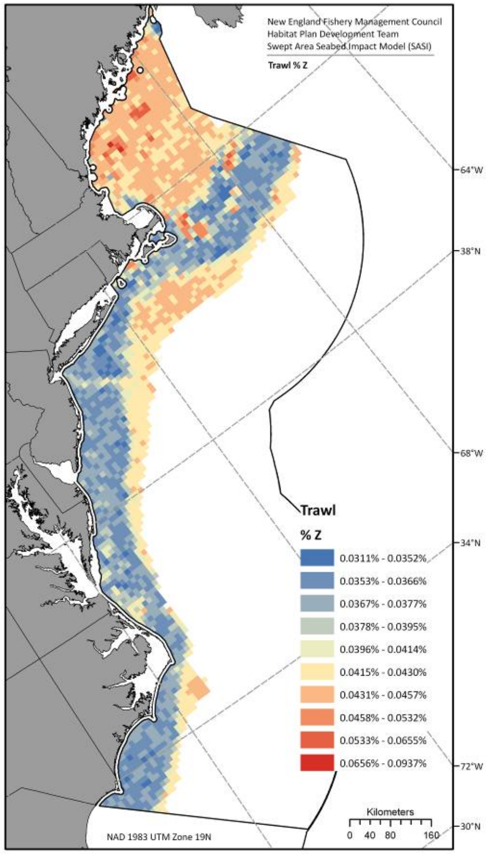
Fishing effort simulation

- The effect of the underlying substrate distribution, energy distribution, and S and R scores can be visualized by running the model with simulated (i.e. evenly-distributed) fishing effort



Potential trawl footprint based on max depth:

Percentage of total impact that accumulates in each cell:



Ways to use simulations

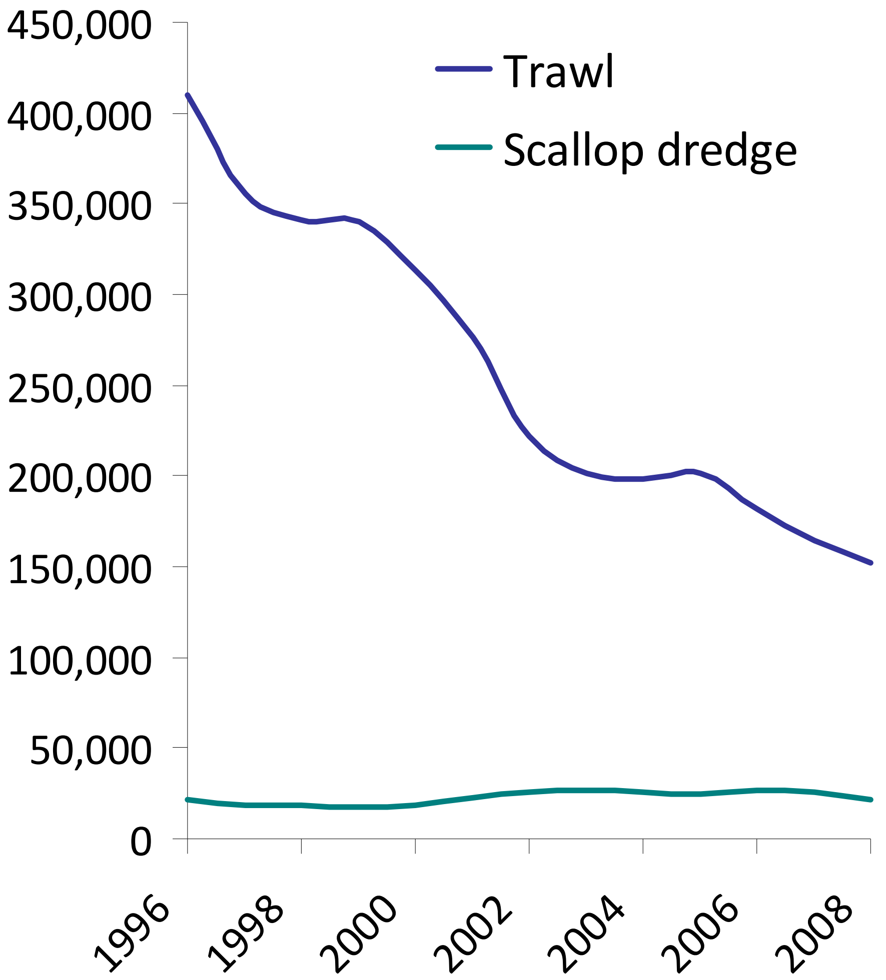
- Evaluate vulnerability of current habitat closed areas using Z estimates for one or more gear types
- Identify potential spatial management areas by looking for locations with relatively high Z for one or more gear types

Realized outputs

- Fishing effort data from VTR, observer, and/or VMS can be used to examine the habitat impacts of actual (realized) fishing events, e.g.:
  - Evaluate the habitat impacts of two effort allocation alternatives by comparing total Z for each alternative
  - Estimate the effects of historical effort reductions and/or shifts in fishing locations by comparing total Z values over time
  - Compare the magnitude of habitat impacts that result from different fisheries/FMPs

Nominal area swept

- Nominal area swept that has not been run through the model and adjusted for vulnerability is nonetheless a useful measure of change over time:



Nominal area swept for trawls and scallop dredges (km^2)

Strengths of SASI

- The model allows for an objective comparison of vulnerability between areas
- Puts effort data for all gear types in the same units, allowing for comparisons between fisheries
- Incorporates more substrate data than previously available into management decision making
- Documents gaps in knowledge of fishing gear impacts, habitat data, and fishing effort data
- Model grids, susceptibility and recovery parameters, etc. may be updated as new data become available

Limitations of SASI

- Spatial resolution of realized fishing effort data is coarse (for VTRs, at the trip level)
- The effects of different gear configurations (i.e. types of trawl sweeps) on area swept and impact can be modeled by modifying contact indices, but data are not available on the actual frequency of use of different configurations. In addition, little information is available to inform estimation of contact indices
- Data on substrates larger than granule-pebble are not available in some areas, especially in deeper waters
- Currently, model domain excludes areas inside 3 nm
- Since SASI time step is 1 year, adverse effects on shorter time frames cannot be examined