Identifying and Comparing Ecosystem Stressors in the Eastern Bering Sea and Gulf of Alaska

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Goals

Develop metrics to represent the condition of marine ecosystems in Alaska that can be used to:

1. establish reference points useful for Alaska's Integrated Ecosystem Assessment (IEA)
2. enable comparisons across ecosystems in Alaska

Methods

1. **Query EBS and GOA ecosystem experts on habitat (n=20) X pressure (n=22) interactions.**

2. **For each pressure x habitat interaction, calculate the score (1-4) and certainty (1-4) of:**
   - 3 vulnerability indices:
     1. *Spatial extent*
     2. *Frequency*
     3. *Trophic impact*
   - 2 Resiliency indices:
     1. *Impact resistance*
     2. *Recovery time*

3. **Calculate Risk and Ecosystem Condition:**

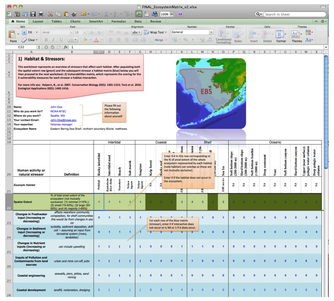

Figure 1. Section of matrix used to query ecosystem experts on habitat x pressure interactions in Alaskan marine ecosystems.

$$K_h = \frac{V_h}{R_h}$$

where,

$$V_h = \sum_{p}^{p} V_{ph}$$

$$R_h = \sum_{p}^{p} R_{ph}$$

$$V_{ph} = X_{ph} \cdot \left(\frac{\sum V_{phi}}{n_V}\right)$$

$$R_{ph} = X_{ph} \cdot \left(\frac{\sum R_{phi}}{n_R}\right)$$

$$q_p = 100 \cdot \frac{q_p^{'} - q_{min}}{q_{max} - q_{min}}$$

where,

$$q_p^{'} = \left[\sum^{n_h} \left(\frac{A_h \cdot X_{ph}}{\sum A_h \cdot X_{ph}}\right) \cdot q_{ph}\right]^{-1}$$

$$q_{ph} = \left(\frac{\sum V_{phi}}{n_V} + \frac{\sum R_{phi}}{n_R}\right) \cdot \frac{1}{2}$$

$$V_{phi} = I_{V_{phi}} \cdot e^{\left(1-\alpha_{c_{phi}}\right)}$$

$$V_{phi} = I_{V_{phi}} \cdot e^{\left(1-\alpha_{c_{phi}}\right)}$$

Parameter	Definition
c	Certainty
p	Pressure
h	Habitat
v_h	Habitat specific vulnerability
r_h	Habitat specific resiliency
V_p	Pressure specific vulnerability
R_p	Pressure specific resiliency
A_h	Habitat specific area
n_R	Number of resiliency categories
n_V	Number of vulnerability categories
n_h	Number of habitats
n_p	Number of pressures
$I_{V_{phi}}$	Vulnerability index for each category i of p x h interaction (1-4; L to H)
$I_{R_{phi}}$	Resiliency index for each category i of p x h interaction (1-4; H to L)
$I_{c_{phi}}$	Certainty index for each category i of p x h interaction (1-4; L to H)
$\alpha_{c_{phi}}$	Uncertainty penalty for each index $I_{c_{phi}}$ [0.15, 0.5, 0.75, 1.0]
X_{ph}	h X p interaction value (0 or 1)
K_h	Habitat-specific risk score
q_p	Pressure-specific ecosystem condition

Results

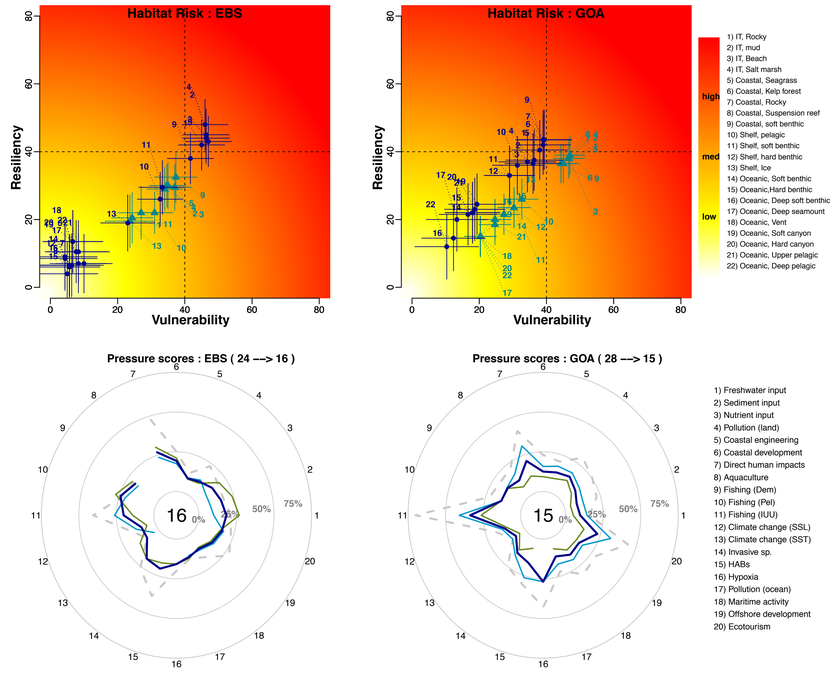

Figure 2. (Top) Habitat specific risk (cumulative for all pressures) for EBS and GOA ecosystems based on results of surveys from reviewers 1 and 2 (circles and triangles, respectively). Adapted from Samhouri and Levin (2012). Error bars represent uncertainty indices for each habitat (scored from 1 to 4; low to high). (Bottom) Pressure specific index scores for EBS and GOA ecosystems based on results of surveys from reviewers 1 and 2 (light blue and green lines, respectively). Values are based on area-weighted mean scores across habitats for each pressure and penalized for uncertainty. The dark blue line represents the mean value for both reviewers. Non-penalized mean values are shown in the dotted gray line. Values at the center of the plot are the over-all ecosystem score (out of 100), based on mean penalized scores for each pressure. Modified from Halpern et al. 2012.

Most habitats scored low and moderate for risk
- Oceanic and hard bottom habitats had lowest risk scores.

Ecosystem condition scores were low
- Climate change, coastal engineering, and maritime activity were the largest pressures of concern.
- Scores may be too sensitive to pressures (lower than expected).

Uncertainty was high
- Lack of published papers on system-specific vulnerability and response to pressures lead to high uncertainty penalties.

Survey response rate was low
- Matrix entry too time consuming.
- Subject areas often did not match expertise of respondents.

Conclusions

- Approach provides a framework for deriving ecosystem reference points for management and can be used for ecosystem risk assessment and management prioritization.
- Climate change (future), maritime activities, coastal engineering, and fishing are the greatest ecosystem stressors in the eastern Bering Sea (EBS) and Gulf of Alaska (GOA).
- Survey approach needs to be optimized to increase participation; expert opinion should target specific habitats or pressures.

Future Directions

Data collection:
- Streamline expert surveys by fitting the survey to the experts' knowledge, thereby reducing the overall size and breadth of the survey.
- Convene a workshop to gather group consensus on estimates and error.

Data analysis:
- Conduct sensitivity analysis on index and risk value results.
- Conduct cluster analysis to identify habitats that respond similarly to pressures.
- Add human dimensions to matrix.

Application:
- Conduct risk assessment and management strategy evaluations (i.e., alter input values).

Acknowledgements

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