SASI Model Applications

NEFMC SSC Meeting

25 August 2010

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Documents

1. TOR memo
2. SASI background document part 1
3. SASI background document part 2
4. Sensitivity analyses
5. **Spatial analyses – LISA and EAP***
6. **Z Net Stock model (practicability)***

* Focus of presentation

One page Z definitions handout

Outline

- Background and context for spatial and practicability analyses (Michelle)
- Brief review of SASI results (Chad)
- Summary of spatial analyses objectives, methods, and results (Brad)
- Summary of practicability analysis objectives, methods, and results (Chad)

The MSA requires FMP's to:

"Describe and identify essential fish habitat for the fishery …

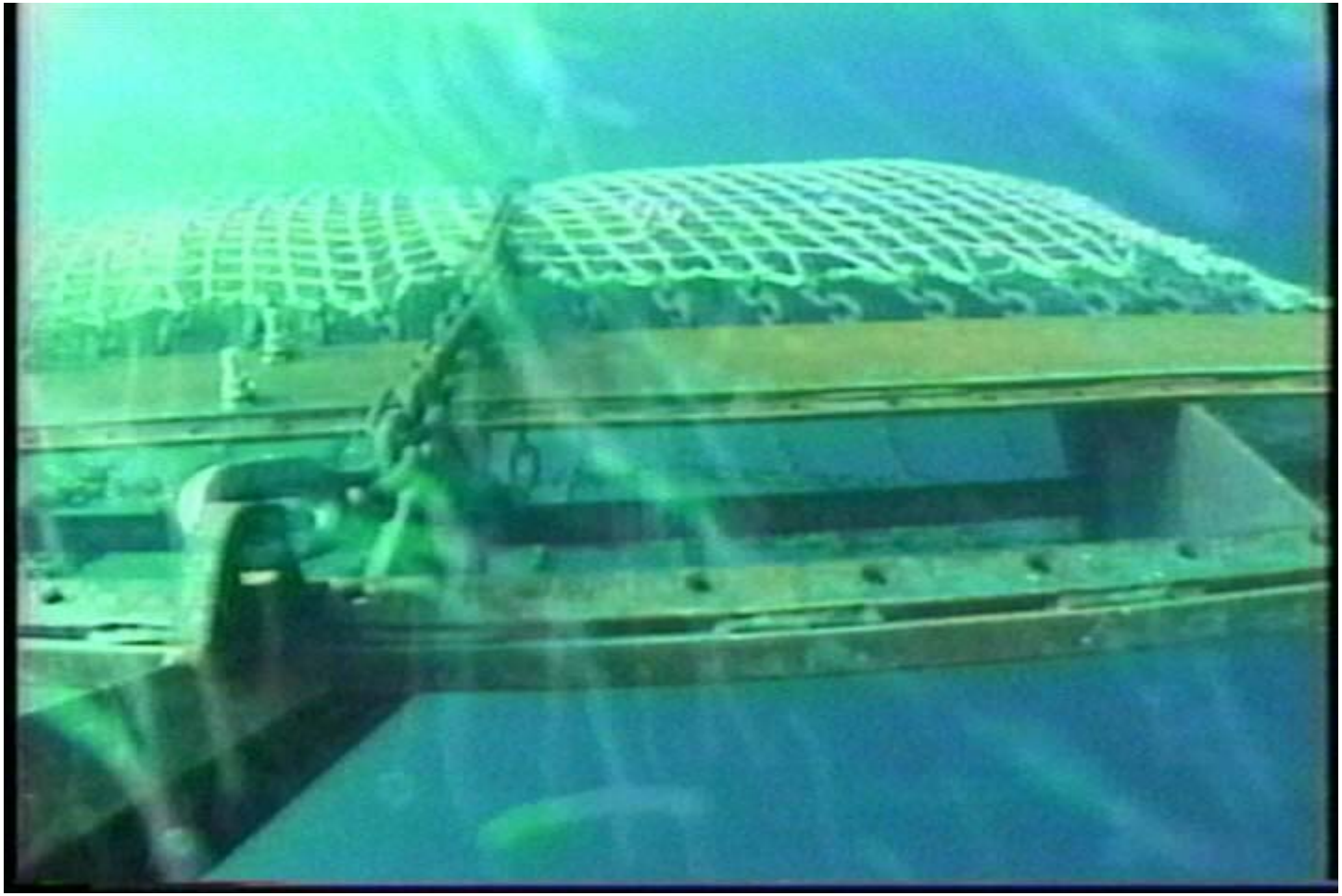
…**minimize to the extent practicable adverse effects on such habitat caused by fishing**, and

identify other actions to encourage the conservation and enhancement of such habitat"

Adverse effects determination
(from EFH Final Rule)

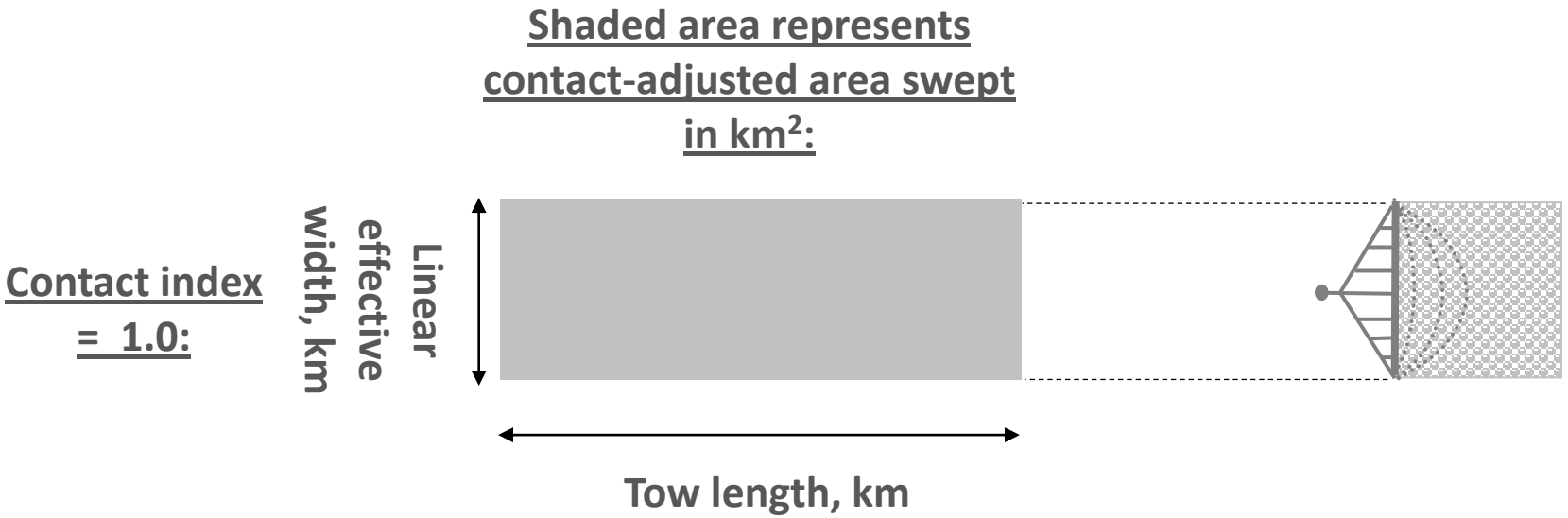
- Each FMP must provide conclusions regarding whether and how each fishing activity adversely affects EFH
- If effects are adverse, they should be minimized to the extent practicable
- Definition of ‘adverse’ is based on a more than minimal/not temporary threshold

Video



Area Swept

- Area swept is the foundation of the adverse effect estimate



Estimating adverse effects (Z)

- SASI estimates adverse effects across time and space

Gears Tows/sets

A – Area swept
λ – recovery
ω – susceptibility

$$Z_{t+1} = Z_t + \left[\sum_{i=1}^{10} \sum_{j=1}^{n} \sum_{k=1}^{5} \sum_{l=1}^{2} \sum_{m=1}^{26} \left[\left(\lambda \left(\mathrm{A}_{i,j} \omega_{k,l} \right)_{t_0} \Delta t \right) - \left(\mathrm{A}_{i,j} \omega_{k,l} \right)_t \right] \right]$$

Substrates Energies Features

SSC Review #1 – 11 March 2009

SSC conclusions:

- Literature review adequate
- Matrix-based structure appropriate, but biological components must be addressed
- Analytical approach of swept area for fishing effort appropriate
- General approach to overlay habitat and fishing effort appropriate, but methodological refinements needed:
  - analysis of heterogeneous data
  - inference of energy levels from shear stress
- Formal and transparent method needed for derivation of sensitivity criterion as a function of susceptibility and recovery
- Higher spatial resolution of fishing effort needed

Critical elements of the analysis need to be revised and the method needs to incorporate biological components

SSC Review #1 – 11 March 2009

PDT response:

- Biological features added, geological and biological features inferred to substrate/energy, informed by empirical data
- Area swept models for fixed gears updated, contact indices refined
- Substrate grid updated to smallest unstructured cells possible, rather than aggregating samples
- Fishing effort assigned to regular, 100 km^2 grid cells
- 60 meter depth threshold for high vs. low energy, trawl survey hangs not used as proxy for boulder habitat, additional substrate data added in Gulf of Maine
- Sensitivity approach modified to keep S and R separate, S value used to scale fishing effort and R value used to determine the number of years over which effort decays

SSC Review #2 – 12 Dec 2009

SSC recommendations:

- SASI model technically sound
- Model data may not have adequate resolution to detect subtle differences in habitat impacts among different gear types
- Assumption of additive impact of fishing effort may be more reasonable for some gear types than others
- Some measure of uncertainty in Z needed

SSC review of applications of the SASI model for management decisions would be appropriate

Habitat Oversight Committee Tasking (1-2 April 2010)

Committee asked the PDT to:

- Suggest modifications to the boundaries of the existing closed areas, including the suggestion of any new closed areas and elimination of any closed areas
- Evaluate the appropriateness of the current boundaries of the closed areas
- Provide a metric for understanding and analyzing tradeoffs (i.e. practicability)

SASI results – are effects adverse?

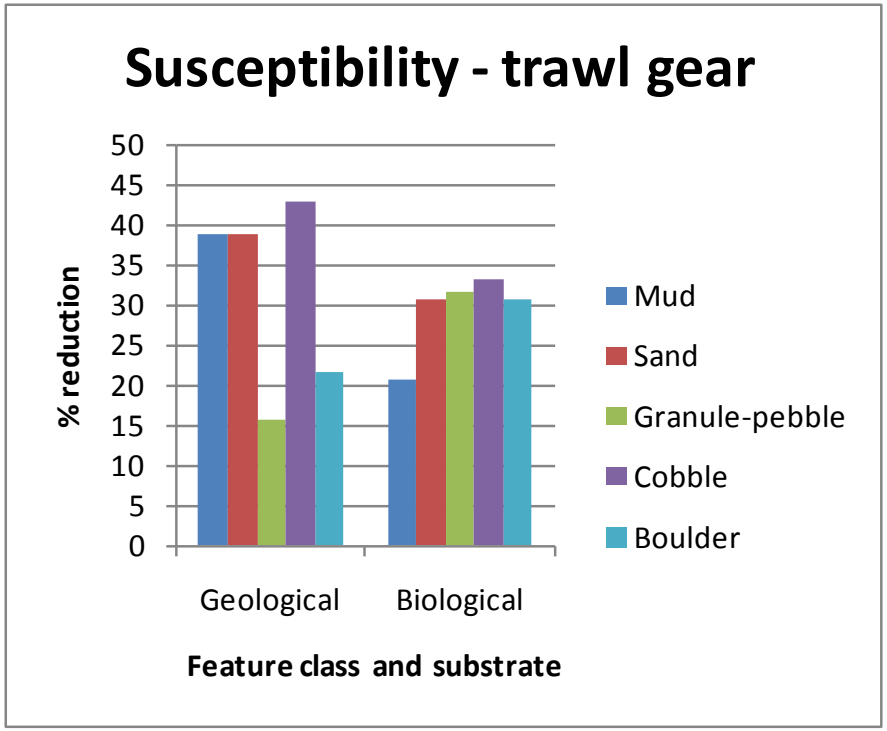
The vulnerability assessment leads us to conclude that all gears may induce effects that are:

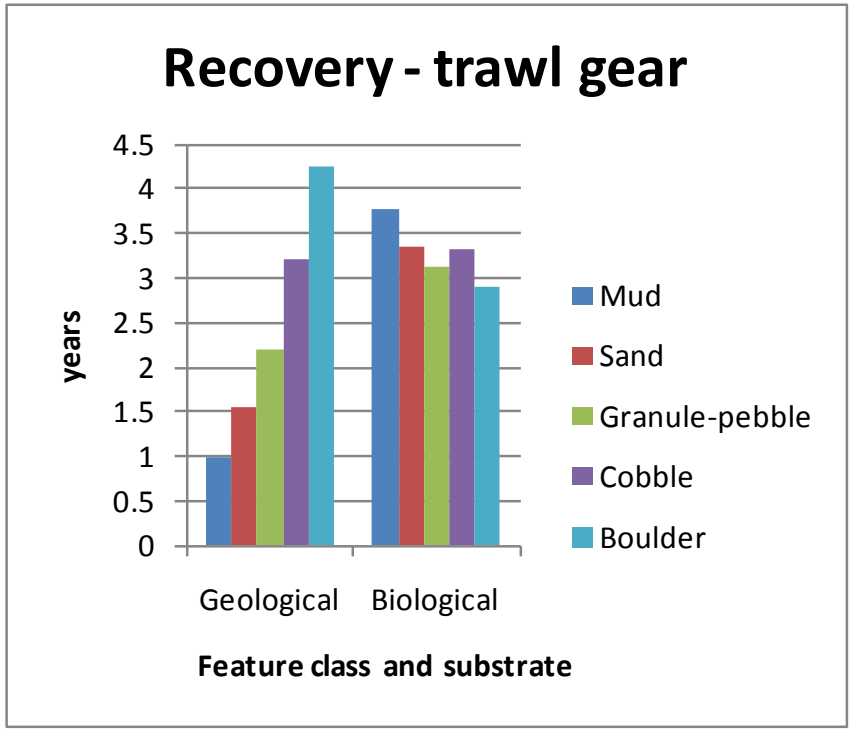
a) more than minimal, i.e. susceptibility > 0; and
b) not temporary in nature, i.e. recovery values > 0

SASI results - % of adverse gear/feature interactions

Gear type	Total number of features	Features with both S and R greater than 0
Trawl	118	94 (80%)
Scallop dredge	118	94 (80%)
Hydraulic dredge	54	49 (91%)
Longline	118	67 (57%)
Gillnet	118	67 (57%)
Trap	118	67 (57%)

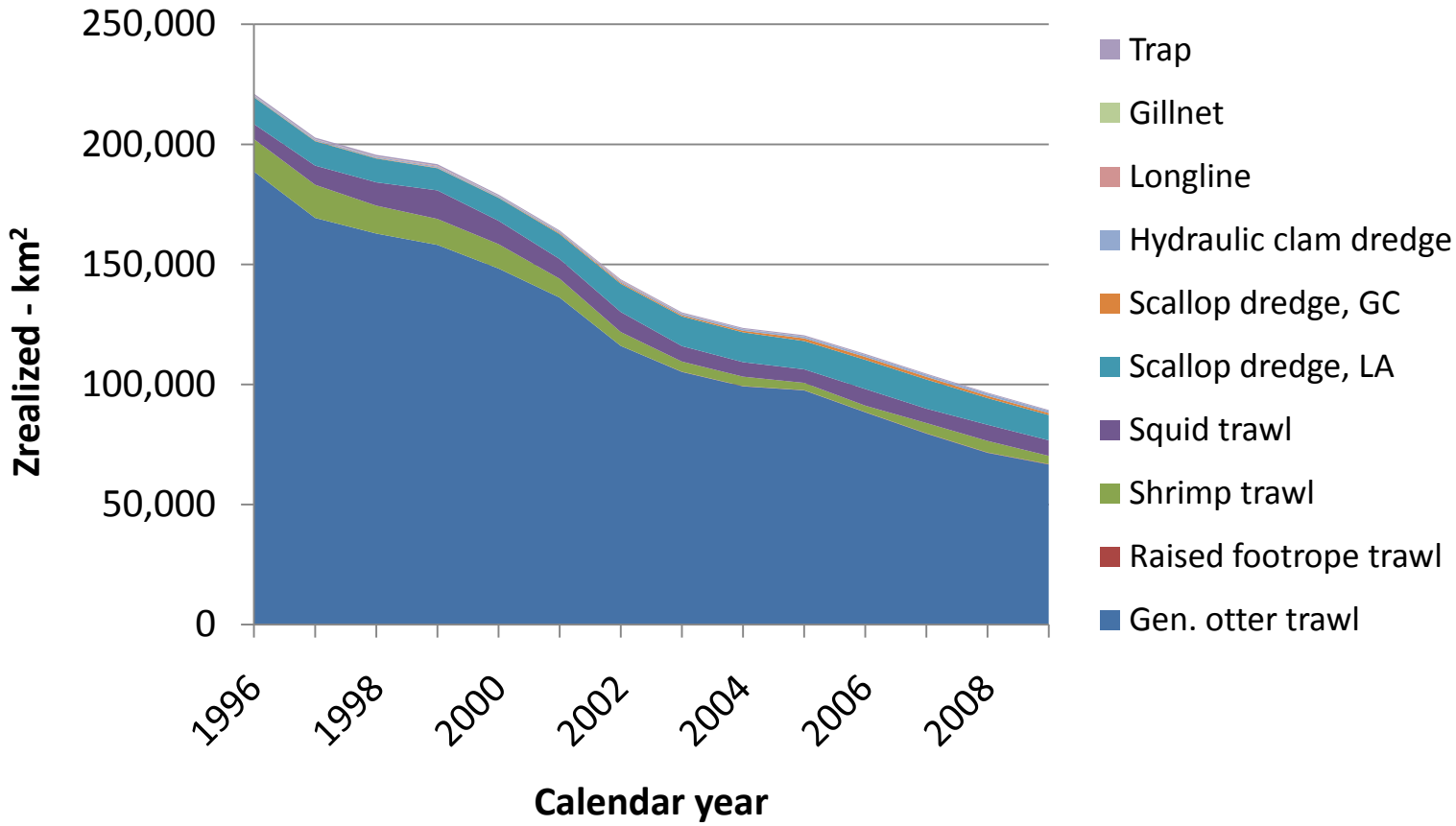
SASI results – what habitat types are most vulnerable?





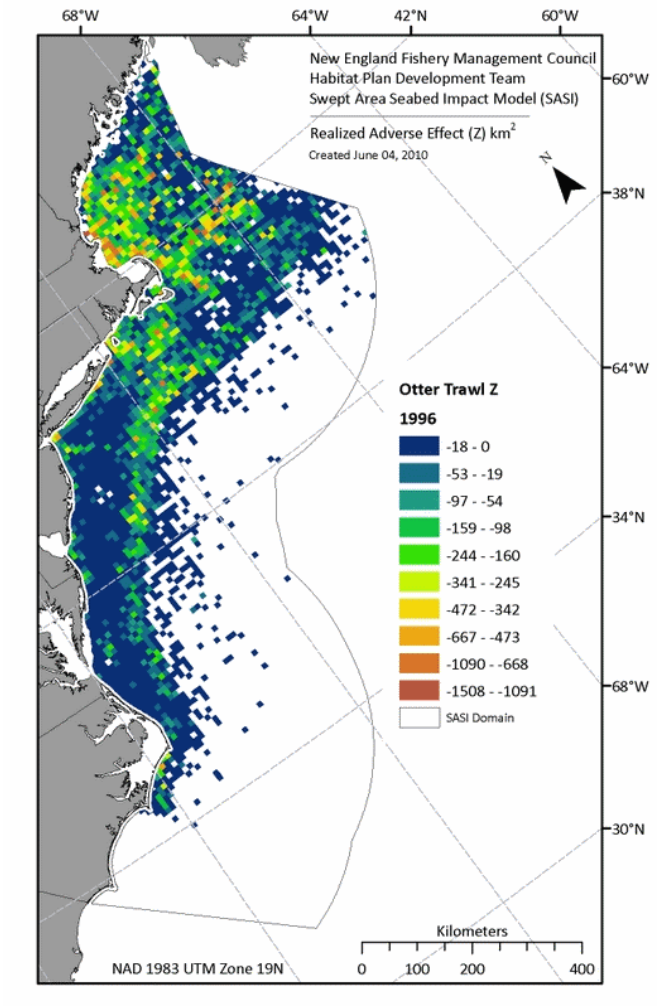
SASI results - $Z_{realized}$

Change over time in realized adverse effects:

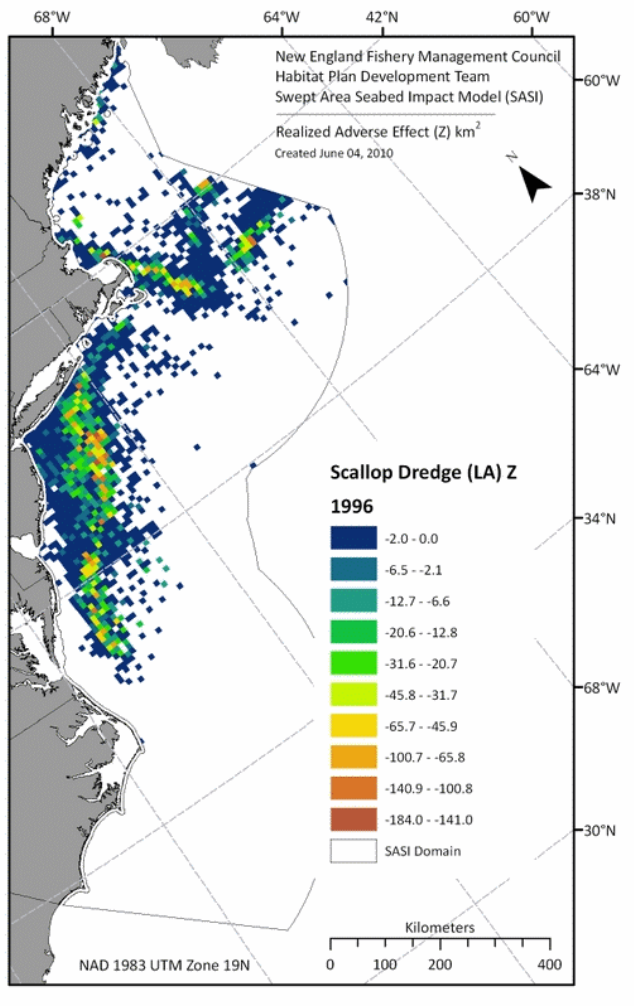


SASI results – $Z_{realized}$

Generic otter trawl



Limited access scallop dredge



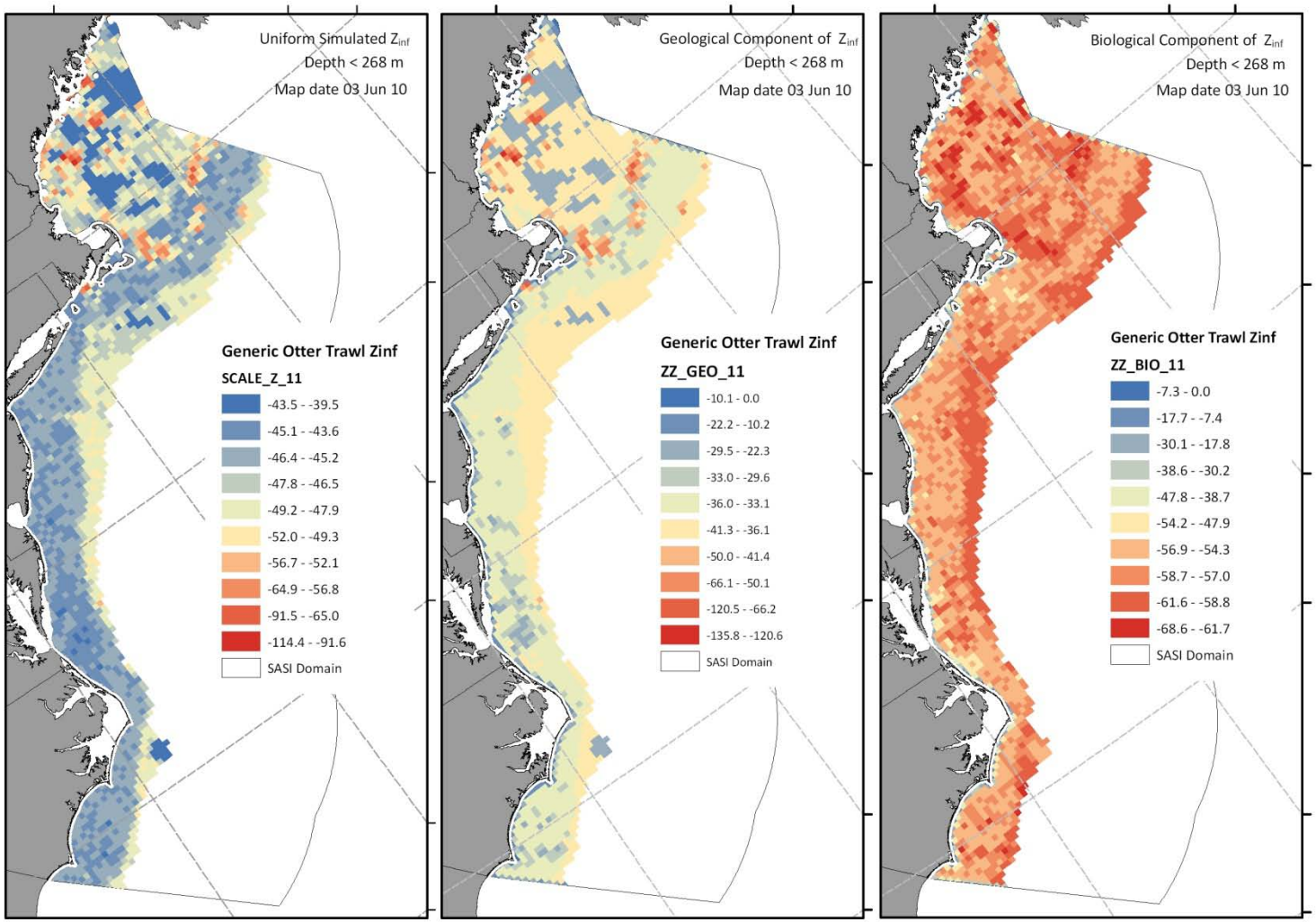
SASI Realized Z Conclusions

- Mobile gears comprise nearly all of the adverse effects from fishing estimated in our region (99.5% in 2009)
  - Trawl gears 85%, dredge gears 14%
- Adverse effects from fishing by all gears have declined by 30% since 2003:
  - Generic otter trawl declined 35%, Limited access scallop dredge declined 15%

SASI results - Z_{∞} by gear type

Gear type	Maximum	25th %ile	50th %ile	75th %ile
Trawl	100.36	44.66	45.67	47.99
Scallop	75.90	47.12	48.12	48.82
Hydraulic	159.93	107.77	109.58	123.33
Longline	27.22	14.65	14.84	15.07
Gillnet	27.21	14.65	14.85	15.06
Trap	28.25	15.95	16.42	17.55

SASI results – generic trawl gear Z_∞



Results – Sensitivity analyses

- SSC recommended looking at uncertainty in model outputs at Dec 2009 meeting
- No way to calculate an estimate of uncertainty around Z values, given model formulation
- However, PDT varied model parameters and evaluated impacts of variation on Z
- Model is robust to various assumptions (see document 4)

Uncertainty in spatial info

- Will be producing two sets of maps:
  - areas with no direct observations
  - areas where Voronoi cells are larger than assessment cells
- These types of uncertainty will affect presentation and application of model results
- Note that SASI designed for use over a large domain, and over interpretation of results in small/localized areas is not appropriate

Terms of Reference

Evaluate the application(s) of the SASI model for use in developing management alternatives for Phase 2 of Omnibus Habitat Amendment 2.

- Evaluate the appropriateness of the LISA spatial analysis methods for defining clusters of high Z∞.
- Evaluate the appropriateness of the Z Net Stock model for comparing practicability among management alternatives.

SASI Spatial Analysis Objectives

1. Explore the spatial structure of the asymptotic area swept (Z_∞)
2. Define clusters of high and low Z_∞ for each gear type
3. Determine the levels of Z_∞ in present and candidate management areas relative to the model domain
4. Identify equal sized areas where Z_∞ was similar to or higher than the tested areas

Local Indicators of Spatial Association

- *Explore the spatial structure of Z_∞*
- *Delimit clusters of model cells with high Z_∞*

$$I_i = \frac{x_i}{Q_i^2} \sum_{j=1, j \neq i}^{n} w_{i,j} x_i,$$

where

$$Q_i^2 = \frac{\sum_{j=1, j \neq i}^{n} w_{i,j}}{n-1} - \overline{X}^2$$

Queen Contiguity

1	2	3
8	$\mathbf{x_i}$	4
7	6	5

Interpretation

$I_i > 0$ = Cluster Member

$I_i < 0$ = Outlier

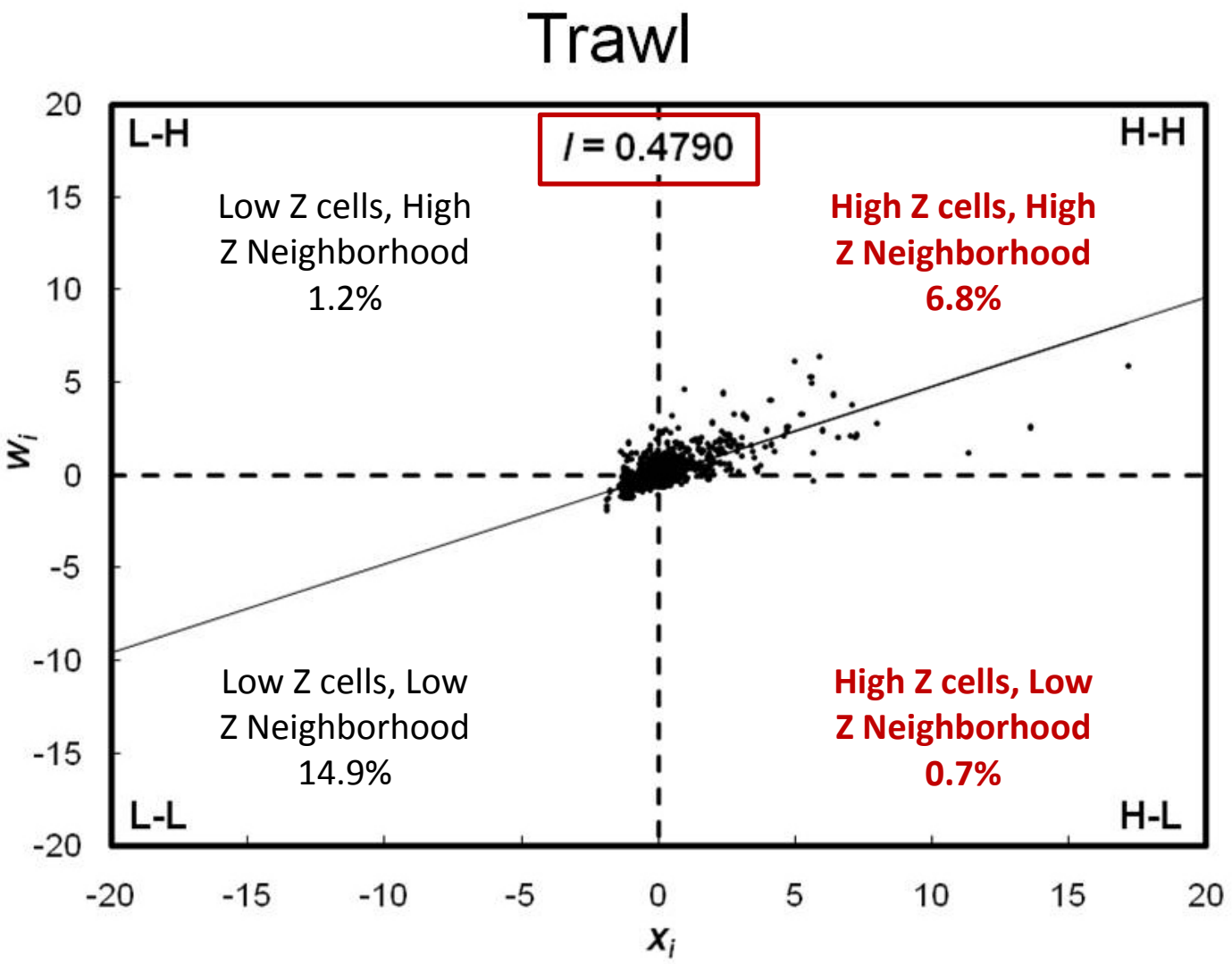
$I_i = 0$ Random

permutation based *p-values*

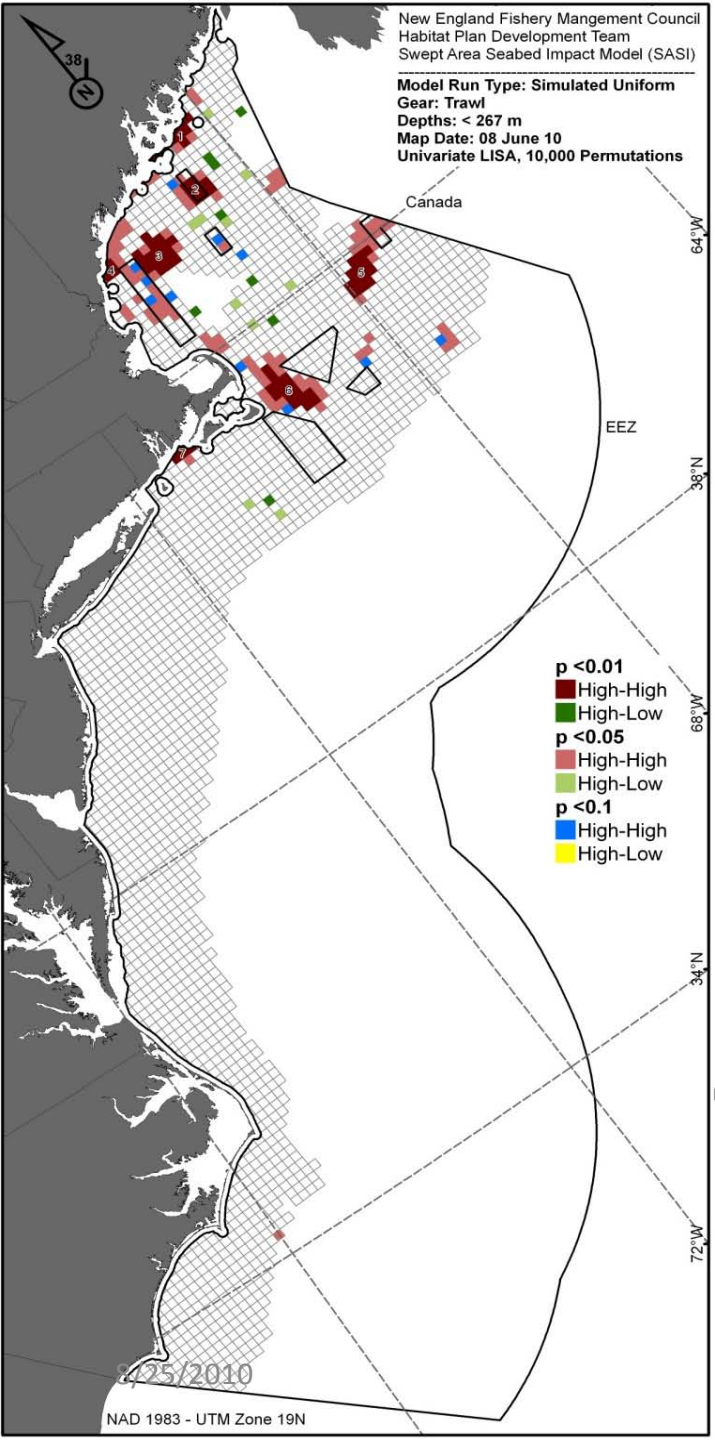
Anselin (1995)

Harris and Stokesbury (*In Press*)

LISA Moran Scatterplot

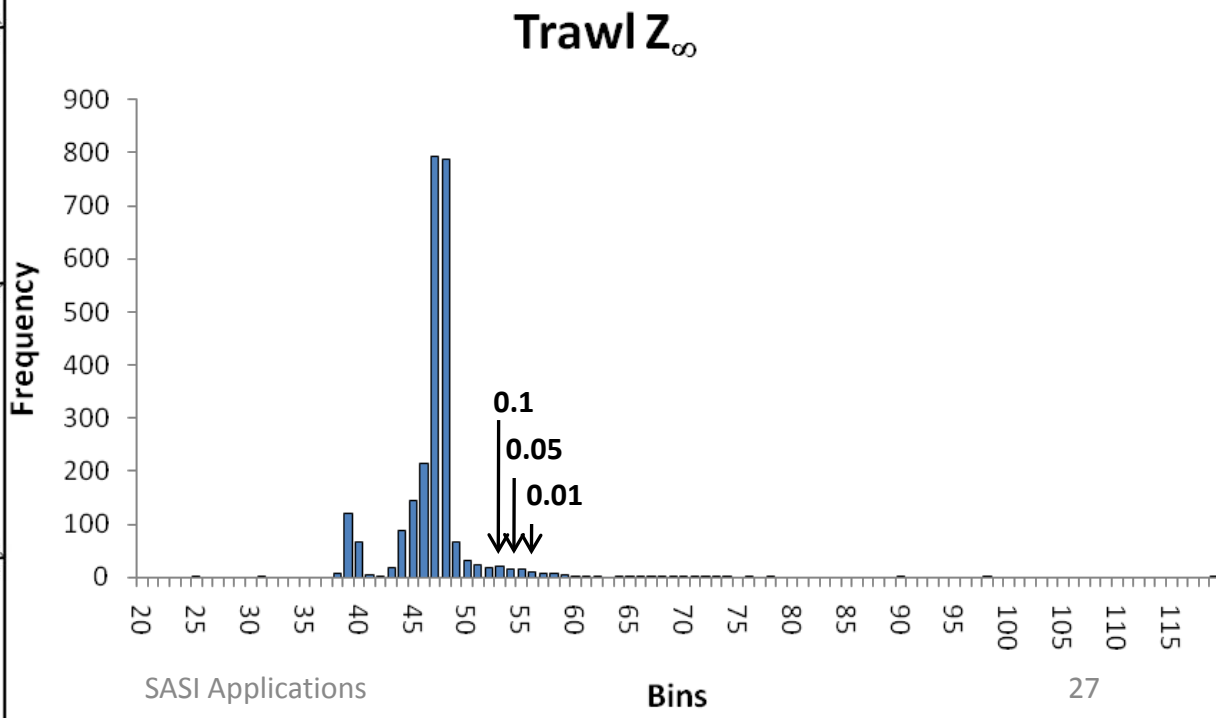


76.3% Not Significant ($p \leq 0.01$)



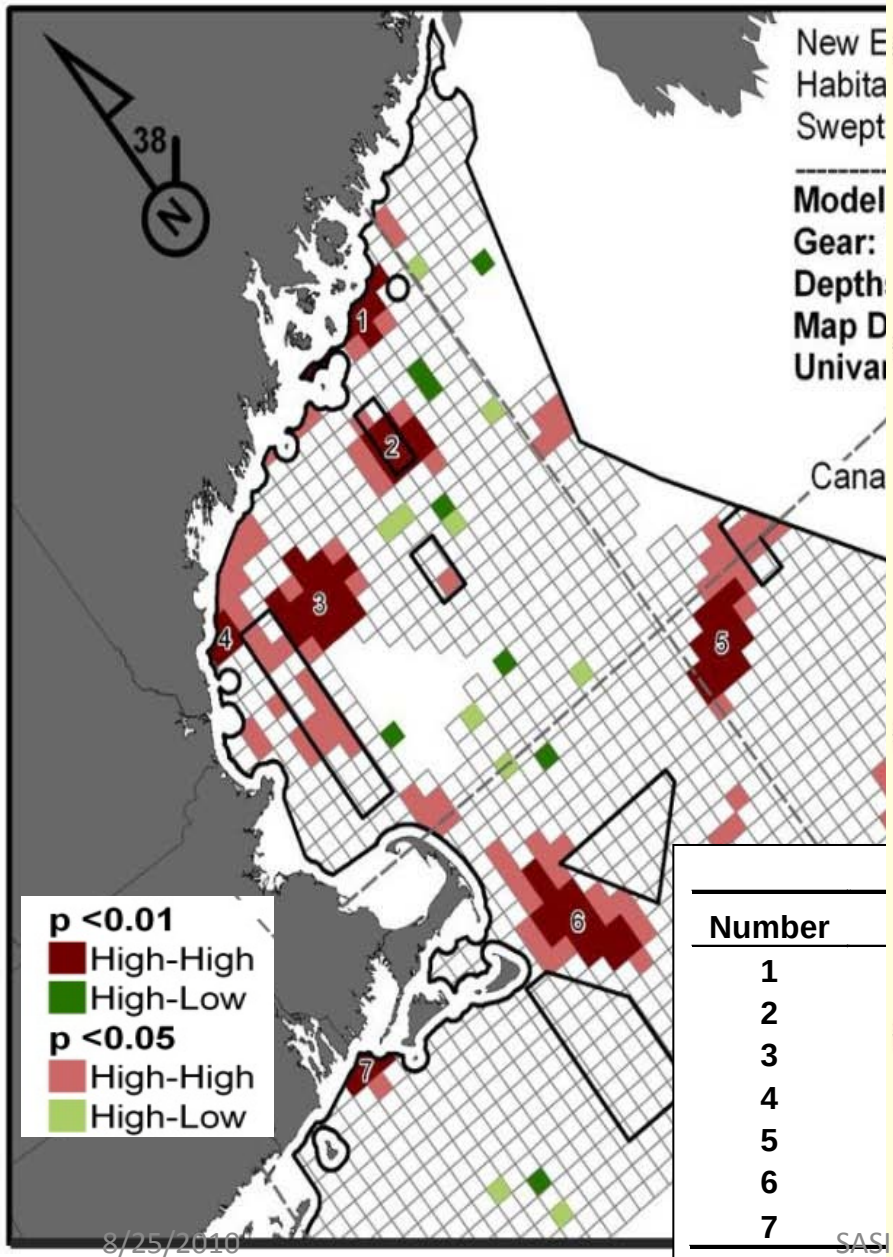
LISA Analysis - Trawl

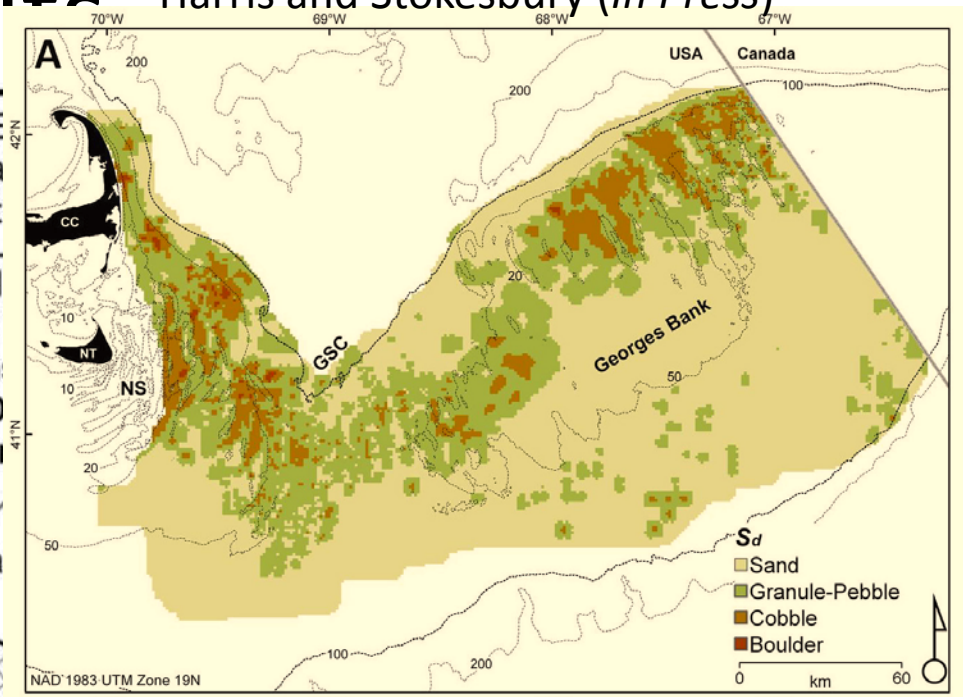
Gear	Global Morans *I*	*p*
Trawl	0.4790	≤0.0001
Dredge	0.5075	≤0.0001
H. Dredge	0.8264	≤0.0001
Gillnet	0.4080	≤0.0001
Longline	0.4100	≤0.0001
Trap	0.6775	≤0.0001

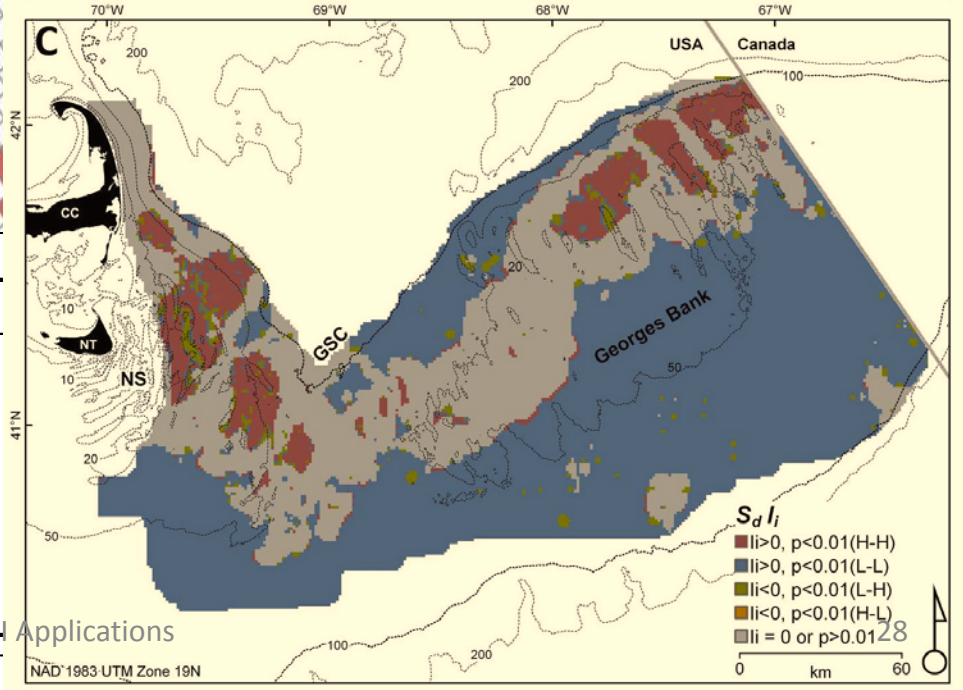


LISA Results

Harris and Stokesbury (*In Press*)







LISA Results

- Global Autocorrelation - Use p-values as "*search tools*"
- Data – LISA results are *relative*
- Sensitivity and p-values → robust spatial results

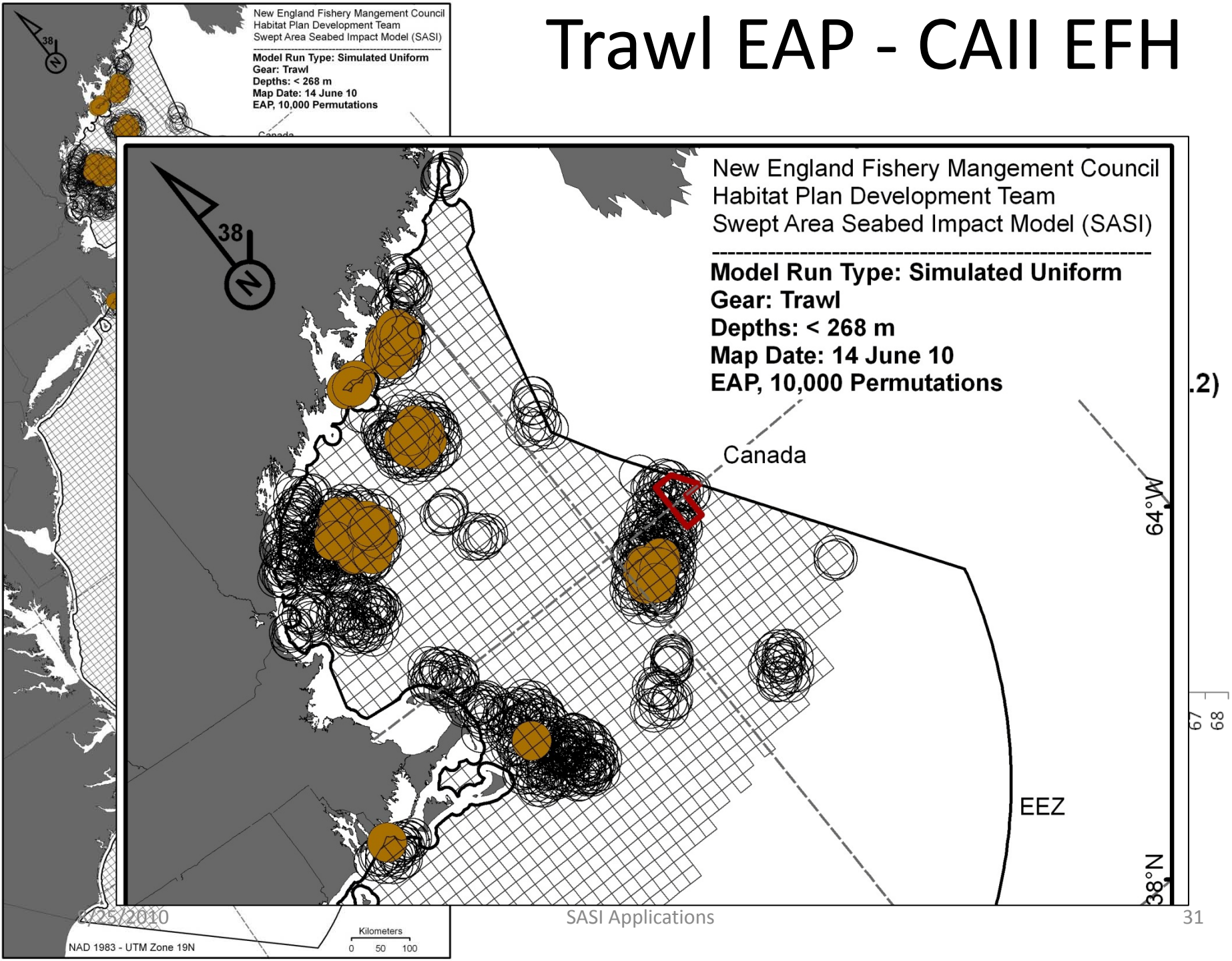
Equal Area Permutation Analysis

-Determine the levels of Z_∞ in present and candidate management areas relative to the model domain

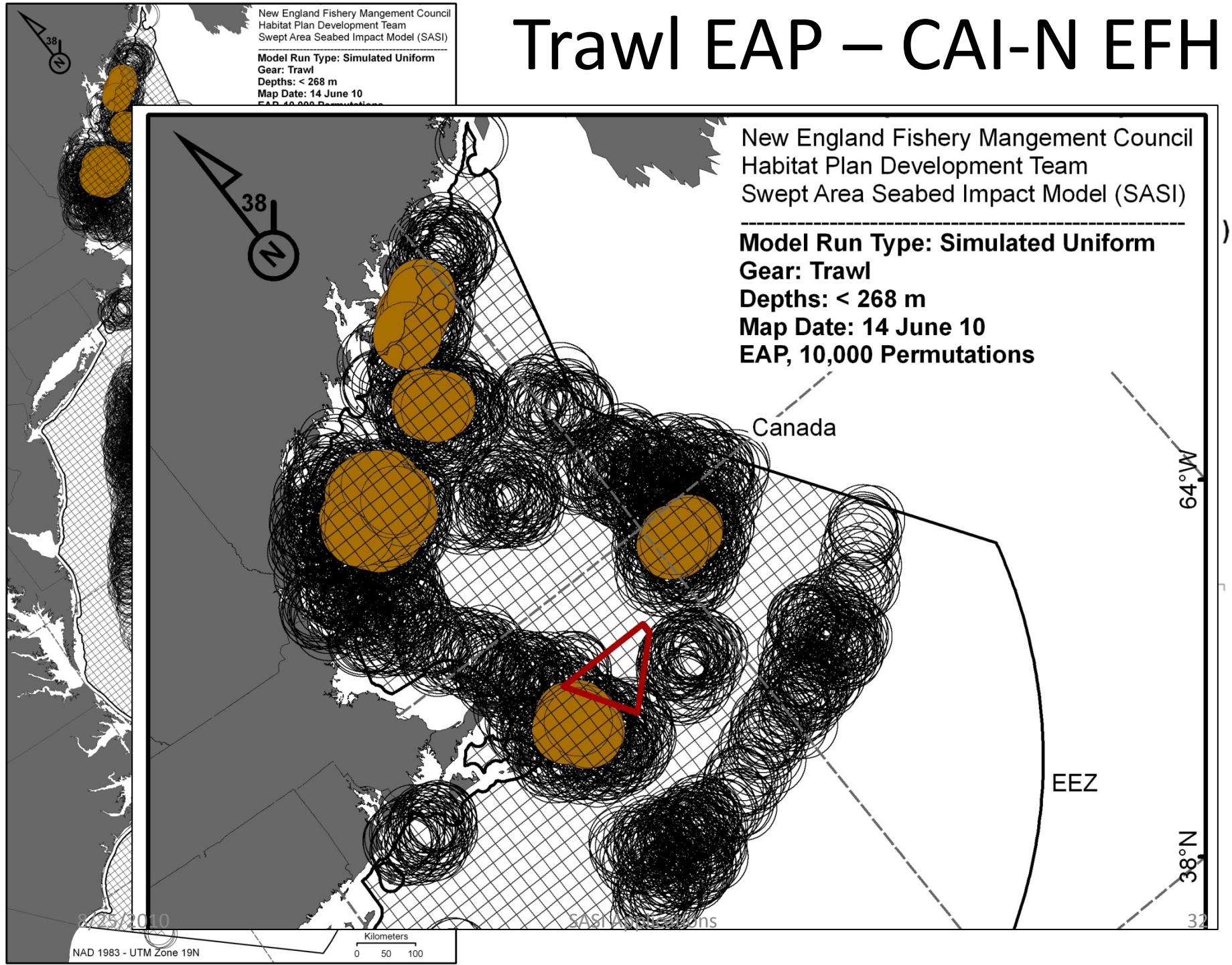
-Identify equal sized areas where Z_∞ was similar to or higher than the tested areas

1. Area-weighted mean z_∞ for each tested area compared to a 9,999 equal sized random areas.
2. Map random areas ≥ to the tested area.
3. Map 100 highest random areas (99^{th} percentile of the permutations distribution).

Trawl EAP - CAII EFH



Trawl EAP – CAI-N EFH



What Next

1. Cluster-specific exploration
2. What areas are masked by low – moderate supporting spatial data?
3. What about practicability…. Chad

Practicability – *e*

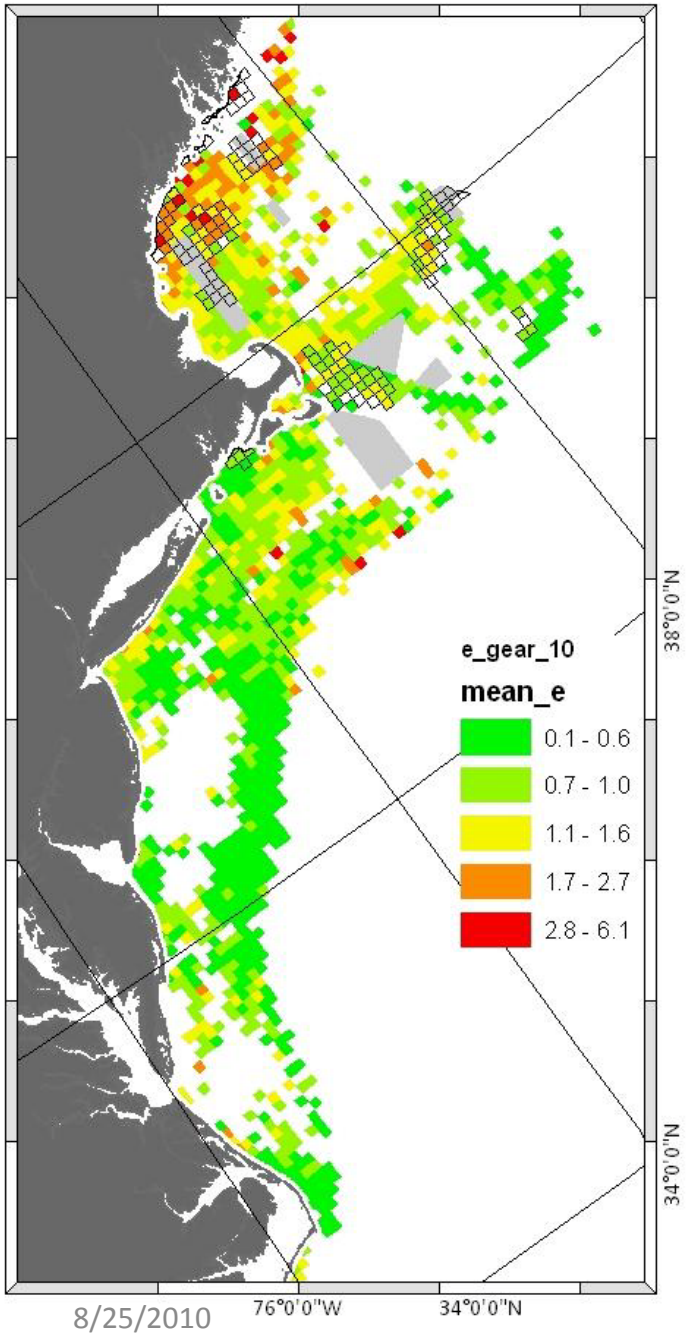
- **Purpose**: To quantify area closure trade-offs and define measurable thresholds for practicable fishing gear adverse effects minimization
- **Application**: Provides a basis for evaluating management scenarios in terms of their ability to reduce habitat impacts while minimizing impacts on fishery profits

e – Background and methods

- Area closure without effort reductions will redistribute fishing effort, often substantially
- There is a trade-off between habitat recovery in closed areas and additional adverse effects in open areas
- To help understand and quantify this tradeoff we use an environmental impact coefficient *e*, where $e_{ip} = \left(\frac{Z^{net}}{X} \right)_{ip}$

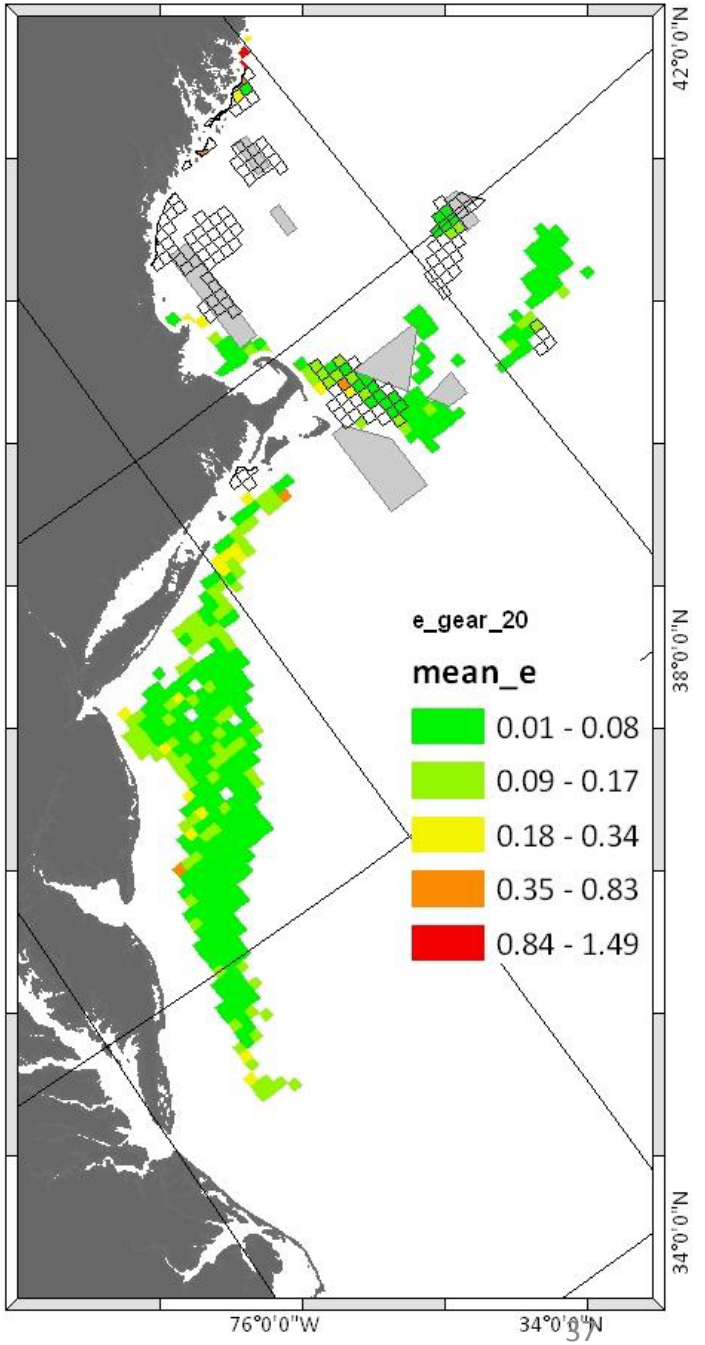
e – Summary results

gear	*e*		z_{net}		*x* (profit)	
	mean	*stddev*	mean	*stddev*	mean	*stddev*
g. otter trawl	0.91	*0.57*	693.7	*886.8*	898.6	*1,097.5*
shrimp trawl	1.28	*0.71*	406.2	*623.7*	374.0	*562.9*
squid trawl	0.67	*0.44*	284.2	*396.5*	545.0	*728.5*
raised trawl	0.47	*0.19*	92.7	*46.6*	203.3	*91.5*
scallop dr, la	0.1	*0.13*	159.7	*147.7*	2,713.7	*2,673.3*
scallop dr, gc	0.16	*0.32*	24.5	*33.5*	252.6	*344.2*
longline	0.04	*0.12*	8.6	*41.3*	284.7	*409.8*
gillnet	0	*0.05*	0.7	*1.8*	544.9	*1,044.3*
pots and traps	0.01	*0.07*	6.3	*17.7*	781.7	*1,387.8*



Scallop dredge =>

Generic otter trawl <=



e – Assessing trade-offs with LISA

Method:

1. Assume LISA cluster parcels closed to fishing
2. Redistribute inaccessible profits proportionally across open areas by holding 2009 profits and their open-area spatial distribution constant
3. Calculate change in total Z_{net}

e – Assessing trade-offs with LISA

Removals:

Gear	% profit closed	% Z_{net} closed
gen. otter trawl	4.6%	10.0%
la scallop dredge	2.3%	2.4%

Redistribution:

Gear	Δ Z_{net}
gen. otter trawl*	3.4%
la scallop dredge	0.1%

*redistribution restricted to cells in the GOM and GB