Omnibus Phase II: Continued development

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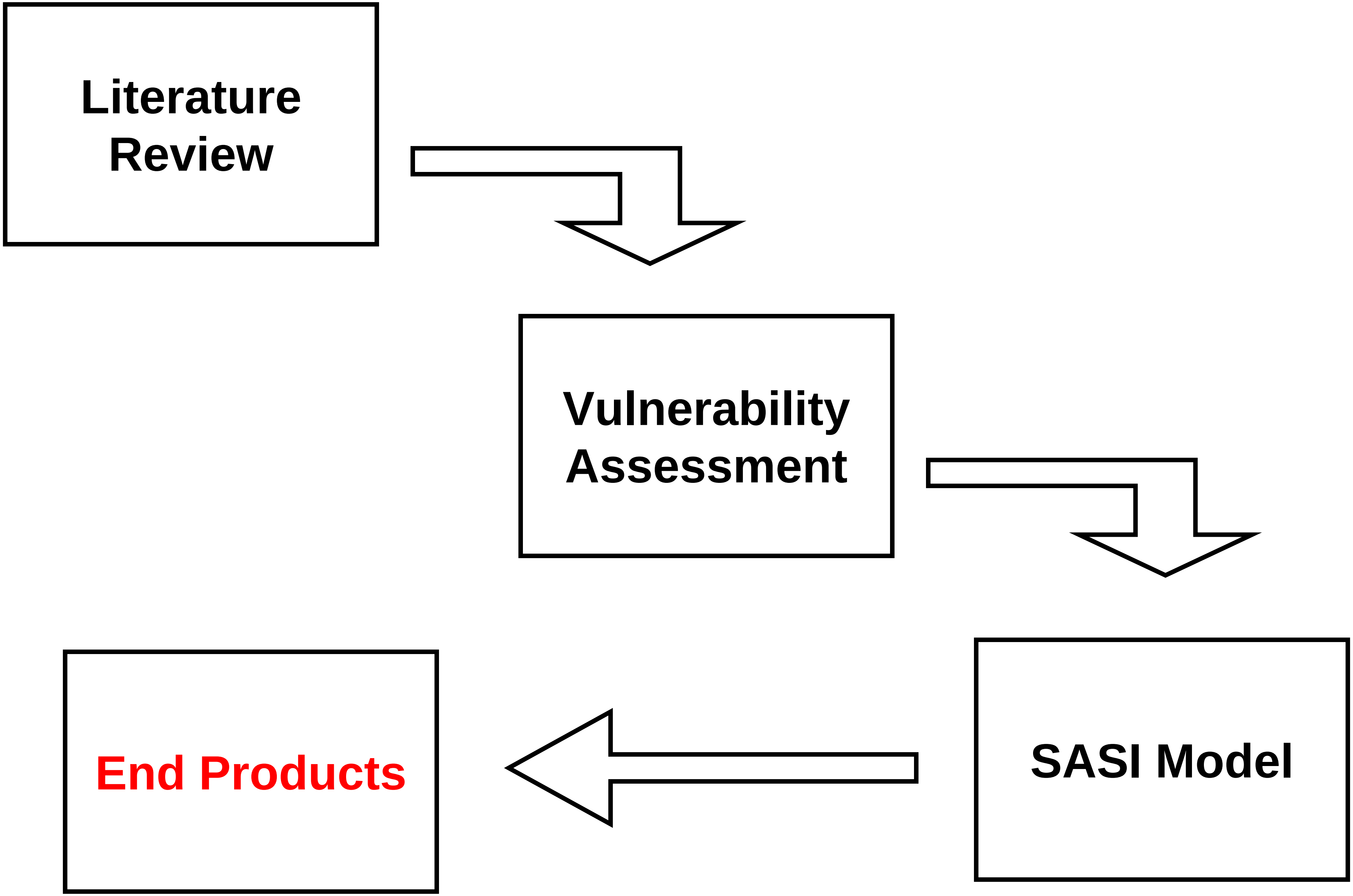
Objective

Describe the components of the matrix and mapping tools being developed by the Habitat PDT to assist the Committee and Council in developing and analyzing alternatives for minimizing the adverse effects from fishing on essential fish habitat to the extent practicable


Literature Review
Vulnerability Assessment
SASI Model
End Products

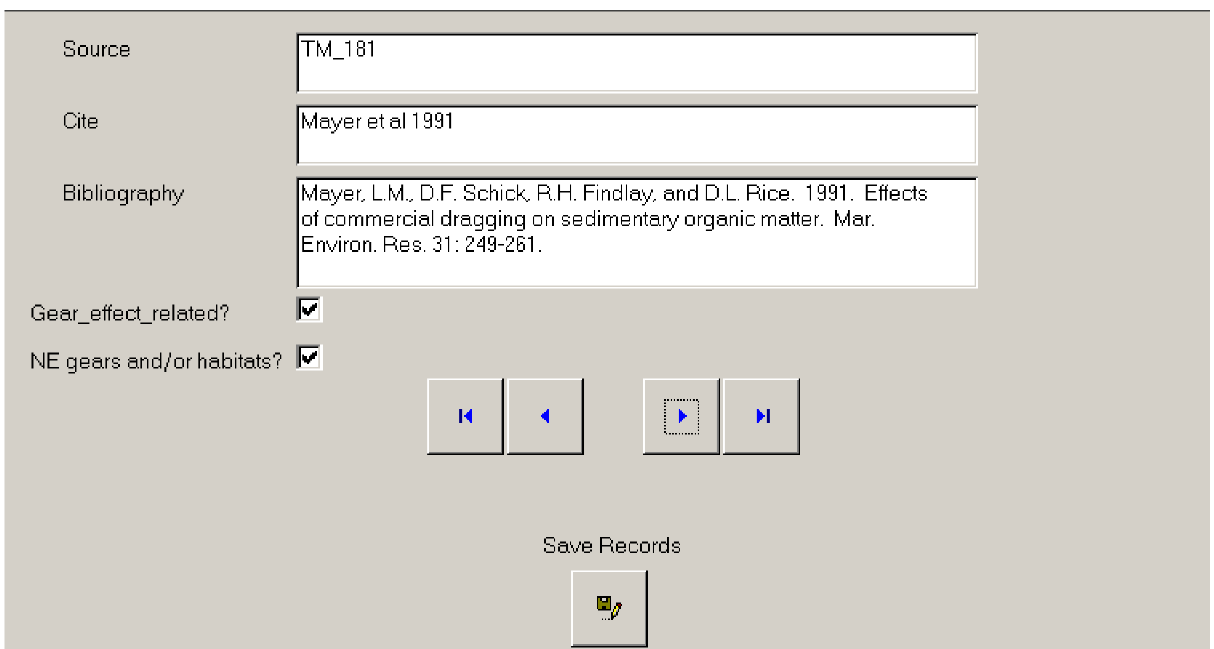
Literature review

- Foundation
- Comprehensive evaluation of applicable published studies
  - Peer-reviewed journals
  - Grey literature
  - Agency studies
  - Prior management documents (NE and other Councils)

Strategy

Create comprehensive database of reference material, including:

- Studies used in previous documents
- Studies conducted since 2003



Results

Database properties:

402 individual published studies

- 228 related to gears under study
- 128 related to both gears and habitats found in study area

Results

Database will contain metadata specific to each study summarizing:

- Data quality
- Study contents and results

ID	Subjective_appropriateness
1	Study tangentially supports VA evaluation
2	Study supports VA evaluation
3	Study perfectly alligned with VA evaluation

ID	Study_design
1	Comparitive
2	Experimental

ID	Relevance
1	Similar gears or habitats but geographically remote study area
2	Geographically similar (though non-NE) study area, similar gears/habitats
3	Study area overlaps with NE area (incl. CA side of Georges) and uses similar gears
4	Studies performed in NE area with NE gears

Results

Database will contain metadata specific to each study summarizing:

- Data quality
- Study contents and results

ID	Geo_component	Wentworth_mm
1	mud-silt	< 0.0625
2	sand	0.0625 - 2
3	granule-pebble	2 - 64
4	cobble	64 - 265
5	boulder	> 265

ID	Geo_gear_effect	Desc
1	Re-suspend	Particles dislodged and suspended in water column
2	Homogenize	Mixing of layered substrates
3	Redistribute	Physical movement of particle over some dist.
4	De-structure	Removal of vertical relief

Summary

Database format advantages:

- Allows for coding of individual studies using categories and effects from assessment matrices
- Hard-codes individual studies to assessment results
- Creates legacy product for future PDT's and Ctte's to build upon

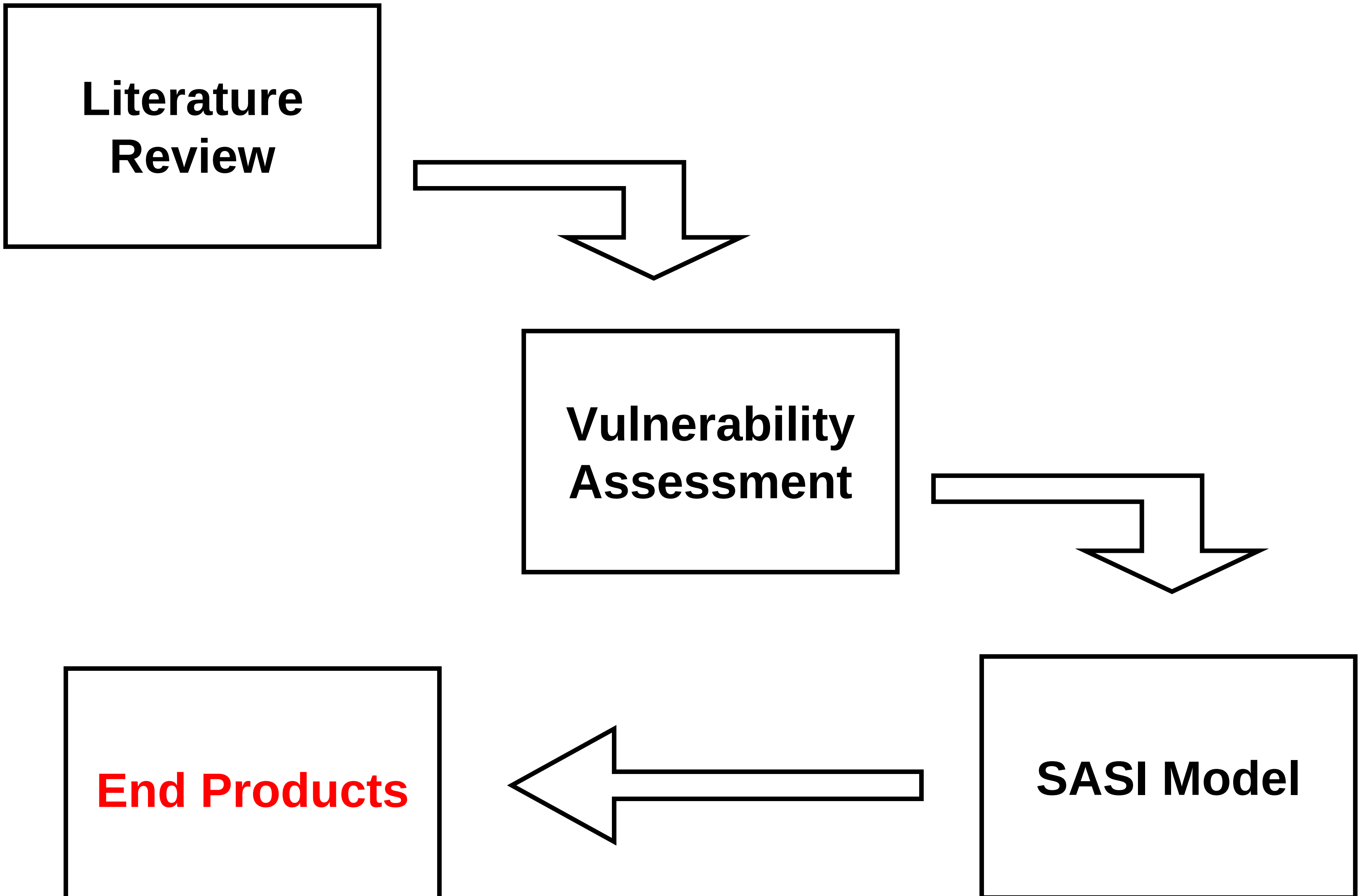
Database format disadvantages:

- Requires a fair amount of labor

Future work

Coding, coding and more coding…

	Field Name	Data Type
	Source	Text
🔑	Cite	Text
	Bibliography	Memo
	Gear_effect_related	Yes/No
	NE_related_habitats_gears	Yes/No
	Study_design	Number
	Study_relevance	Number
	Study_appropriatness	Number
	Energy_depth	Number
	Geological_habitat_component	Yes/No
	Geo_substrate	Number
	Geo_gear_effect	Number
	Geo_suscept	Text
	Geo_recov	Text
	Biological_habitat_components	Yes/No
	Bio_type	Number
	Bio_orientation	Number
	Bio_character	Number
	Bio_strategy	Number
	Bio_gear_effect	Number
	Bio_suscept	Text
	Bio_recov	Text
	Prey_habitat_components	Yes/No
	deep_sea_coral_habitats	Yes/No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Vulnerability assessment

Goal: Categorize and/or quantify the vulnerability of habitats to fishing gears

Method: Literature-based matrix assessment

Outcome: Comprehensive evaluation of the sensitivity of NE habitats to the effects of fishing from NE gears

Overview

A vulnerability assessment is the process of identifying, quantifying, and prioritizing the vulnerabilities in a system

For our purposes, a habitat is vulnerable when it is both *sensitive to* and *capable of experiencing* a gear impact

Concepts

Vulnerability is a function of the sensitivity of a habitat to a fishing gear, and the ability of the gear to impact that habitat

Matrix assumes all NE habitats are capable of being impacted by all NE fishing gears…

Vulnerability = Sensitivity

Defining sensitivity

Sensitivity is a combination of the effects of a fishing gear on the functional value provided by a unit of habitat (*Susceptibility*), and the recovery in functional value that unit of habitat will experience after the gear effect has passed (*Recovery*)

Sensitivity = ***f*** (Susceptibility, Recovery)

where Susceptibility and Recovery may vary across:

- Habitats
- Energy environments
- Fishing gears

Constructing the assessment

Critical assessment elements:

1. ***Habitats***
2. ***Energy environments***
3. ***Fishing gears***

For a matrix-based assessment, these elements must each be defined categorically

Habitats

Fish habitats are continuous and constantly changing; for the assessment, they will be distilled into hierarchical classes that are:

- consistent with the literature
- useful in context

These classes will form the impact surfaces for the assessment…our *Assessment Endpoints*

Assessment Endpoints

The top tier in the hierarchical classification of habitats

- **Geological habitat components**
- **Biological habitat components**
- **Prey species**
- **Deep sea corals**

Geological habitat components

Classified in two sub-tiers, *Class* and *Substrate*

Defined in terms of *dominance,* which is established by volume, area or frequency of occurrence in replicate samples (depending on the sampling design and device)

Geological habitat components

Geological Habitat Components

	Class	Substrate	Wentworth Scale
Dominated	Muds	Mud-Silt	< 0.0625
	Sands	Sand	0.0625 - 2
	Gravels	Granule-Pebble	2 - 64
		Cobble	64 - 265
		Boulder	> 265

Biological habitat components

Classified in four sub-tiers:

1. Type (*Epifauna/Infauna)*
2. Orientation (*Emergent/Encrusting/ Burrowing)*
3. Character (*Hard/Soft)*
4. Strategy *(R-Selected/K-Selected)*

Biological habitat components

Biota			
Type	**Orientation**	**Character**	**Strategy**
Epifauna	Emergent	Hard	r
			k
		Soft	r
			k
	Encrusting	Hard	r
			k
		Soft	r
			k
	Emergent	Hard	r
			k
		Soft	r
			k
	Encrusting	Hard	r
			k
		Soft	r
			k
Infauna	Emergent	Hard	r
			k
		Soft	r
			k
	Burrowing	Hard	r
			k
		Soft	r
			k
	Emergent	Hard	r
			k
		Soft	r
			k
	Burrowing	Hard	r
			k
		Soft	r
			k

Prey species and Deep Sea Corals

These are still undergoing intensive discussion and development…

Energy environments

Environments with different energy characteristics are created by the flow of water over habitats

These energy environments affect the:

- nature of fishing gear impacts (i.e. loss of functional value)
- susceptibility of habitats to fishing gears
- habitat recovery rates

Energy environments

Energy alters gear effects across all combinations of geological and biological habitat components

Fishing gear impacts will be evaluated under two energy environments:

1. High Energy = CSS ≥ threshold, *or*

   Depth < threshold

2. Low Energy = CSS < threshold

Gear effects

Gear effects are a function of the type of gear used, the quality/degree of contact that gear has with a given habitat, and the functional value provided by that habitat:

Effect = f (Gear type, Gear impact, Habitat component)

Gear types

Based on data from the literature and fishing practices within our area, the PDT has narrowed the matrix assessment to 10 gear categories:

Otter trawl	Shrimp, groundfish and scallop
	Monkfish
	Squid
	Raised footrope
	Pelagic
Dredge	New Bedford-style scallop
	Surf clam/ocean quahog
Trap	Lobster
	Deep sea red crab
Longline	
Gillnet	

Gear impacts

Gear impacts will have effects that vary with the habitat components they encounter…these have been aggregated into the following nine categories:

1. Crushing
2. Slicing
3. Ploughing
4. Scraping
5. Creasing
6. Burying
7. Compressing
8. Breaking
9. Fluidization

Gear effect classes

These *impacts* result in *effects* that vary across the habitat components encountered

These *effects* may be broadly classified based on the literature

Four *effect classes* are being considered for each combination of gear/habitat component/energy environment

Gear effect classes

Geo_gear_effect	Description
Re-suspend	Particles dislodged and suspended in water column
Homogenize	Mixing of layered substrates
Redistribute	Physical movement of particle over some dist.
De-structure	Removal of vertical relief

Bio_gear_effect	Description
Expose	Base substrate removed causing exposure of organism
Bury	Previously exposed organism burried by substrate
Detatch	Previously attached organism dislodged from feature or substrate
Remove	Feature disoldged and destroyed

Assessing sensitivity

For every combination of *gear type*, *habitat component*, and *energy environment* the PDT will assess:

- Susceptibility (S), and
- Recovery (R)

These are based on the four *gear effects* unique to each habitat component

Metrics for S and R

Susceptibility

Susceptibility Level	**Susceptibility Description** (*example*)
0	Positive impacts or no detectable adverse impacts on seabed; no significant differences between impact and control areas in any metrics.
1	Minor impacts such as shallow furrows on bottom or minor damage to emergent biota; small differences between impact and control sites, <25% in most measured metrics.
2	Substantial changes such as deep furrows on bottom or extensive damage to shelter-creating epifauna and infauna; differences between impact and control sites 25 to 50% in most metrics measured.
3	Major changes in bottom structure such as re-arranged boulders; large losses of many organisms with differences between impact and control sites >50% in most measured metrics.

Recovery

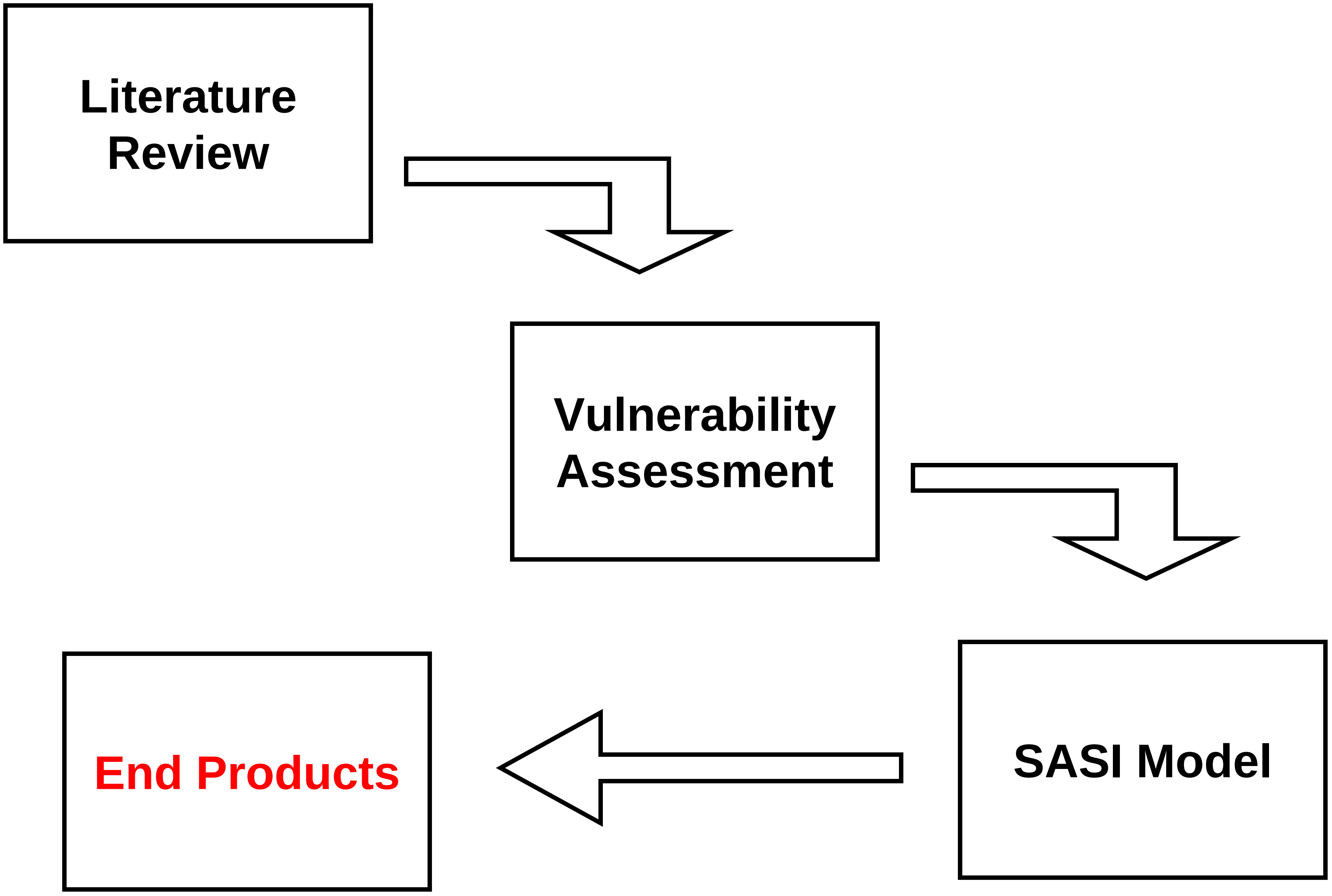
Recovery Level	**Recovery Description** ***(example)***
0	Recovery to pre-impacted state is not possible
1	Habitat able to function at levels similar to pre-impact on decadal or multi-decadal scale
2	Habitat able to function at levels similar to pre-impact on multi-year scale
3	Habitat able to function at levels similar to pre-impact within one year

Geological habitat components

					Gear Type							
					Gear Effects							
			Geological Habitat		Re-suspend		Homogenize		Redistribute		De-structure	
		Impact Type	Substrate	Energy	**S**	**R**	**S**	**R**	**S**	**R**	**S**	**R**
Dominated	**Muds**	*sli, cru, etc.*	**Mud-Silt**	High	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
					0-3	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
				Low	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
					0-3	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
	Sands	*sli, cru, etc.*	**Sand**	High	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
					0-3	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
				Low	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
					0-3	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
	Gravels	*sli, cru, etc.*	**Granule-Pebble**	High	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
					0-3	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
				Low	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
					0-3	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
			Cobble	High	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
					0-3	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
				Low	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
					0-3	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
			Boulder	High	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
					0-3	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
				Low	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
					0-3	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*

Biological habitat components

Biological habitat components					Gear							
					Gear Effects							
					Expose		Bury		Detach		Remove	
Type	Energy	Orientation	Character	Strategy	S	R	S	R	S	R	S	R
Epifauna	High	Emergent	Hard	r	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
				k	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
			Soft	r	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
				k	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
		Encrusting	Hard	r	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
				k	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
			Soft	r	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
				k	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
	Low	Emergent	Hard	r	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
				k	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
			Soft	r	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
				k	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
		Encrusting	Hard	r	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
				k	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
			Soft	r	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
				k	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
Infauna	High	Emergent	Hard	r	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
				k	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
			Soft	r	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
				k	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
		Burrowing	Hard	r	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
				k	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
			Soft	r	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
				k	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
	Low	Emergent	Hard	r	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
				k	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
			Soft	r	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
				k	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
		Burrowing	Hard	r	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
				k	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
			Soft	r	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*
				k	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*	*0-3*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SASI Model

The ***swept area seabed impact (SASI) model*** provides a measure of the area of seabed contacted by a fishing gear in one unit of effort (tow, net, trap, etc), as scaled by the sensitivity of that habitat to the gear.

The model places emphasis on how the gear is used and ‘rewards’ gears that are modified to reduce seabed contact, such as those designed to ‘skim’ over the seabed or with ground gear raised from the seabed.

Model components – trawl gears

$$\text{SASI } (m^2) = d_t[(2.w_o.c_o.s_o)+(2.w_c.c_c.s_c)+(w_s.c_s.s_s)]$$

where;

d_t	=	distance towed in one tow (m)
w_o	=	effective width of otter board (m)
	=	otter board length (m).sin (angle of attack, α_o)
α_o	=	30^o to 50^o
c_o	=	contact index, otter board
s_o	=	sensitivity index, otter board
w_c	=	effective width of ground cables (m)
	=	ground cable length (m).sin (angle of attack, α_c)
α_c	=	10^o to 20^o
c_c	=	contact index, ground cables
s_c	=	sensitivity index, ground cables
w_s	=	effective width of sweep (m)
c_s	=	contact index, sweep
s_s	=	sensitivity index, sweep

Model components – scallop dredges

$$\mathbf{SASI\ (m^2) = d_t\ (w_{rb}.c_{rb}.s_{rb})}$$

where;

d_t	=	distance towed in one tow (m)
w_{rb}	=	effective width of widest dredge component (m)
c	=	contact index, all dredge components
s	=	sensitivity index, all dredge components

Model components – demersal longline or gillnet

SASI (m^2) = $(d_1.w_1.c_1.s_1)+(d_2.w_2.c_2.s_2)+(d_r.w_r.c_r.s_r)$

where;

d_1 = distance end-weight #1 moves over the seabed (m)
w_s = effective contact patch of weight #1 (m^2)
c_s = contact index, weight #1
s_s = sensitivity index, weight #1
d_2 = distance end-weight #2 moves over the seabed (m)
w_s = effective contact patch of weight #2 (m^2)
c_s = contact index, weight #2
s_s = sensitivity index, weight #2
d_r = distance longline or leadline moves over the seabed (m)
w_r = effective contact patch of longline or leadline (m^2)
c_r = contact index, longline or leadline
s_r = sensitivity index, longline or leadline

The distance that each gear component moves is a function of both movements over the seabed while the gear is fishing (soaking) and during the hauling process. How far each component moves over the seabed is currently not known.

Model components – lobster trap

$$\textbf{SASI (m}^2\textbf{)} = \sum[d_{tn}.w_{tn}.c_{tn}.s_{tn}] + \sum[d_{rn}.w_{rn}.c_{rn}.s_{rn}]$$

where;

n = $1 - \infty$

d_{tn} = distance *n*th trap moves over the seabed (m)
w_{tn} = effective contact patch (width x length) of *n*th trap (m^2)
c_{tn} = contact index, *n*th trap
s_{tn} = sensitivity index, *n*th trap
d_{rn} = distance the *n*th rope moves over the seabed (m)
w_{rn} = effective contact patch of *n*th rope (m^2)
c_{rn} = contact index, *n*th rope
s_{rn} = sensitivity index, *n*th rope

Similar to longlines and gillnets, the distance that each trap component moves is a function of both movements over the seabed while the gear is fishing (soaking) and during the hauling process. How far each component moves over the seabed is currently not known.

Model assumptions

The SASI model assumes the following:

- Fishing gear impact is constant within a tow
- There is constant impact along the entire length of a gear component
- The impact of each gear component is cumulative
- A gear component has the same impact on the epibethos and infauna irrespective of its size, length, weight, design and rigging, unless it translates to reduced seabed impact (contact index)
- Seabed topography and composition is consistent within a tow
- The abundance of epibenthos and infauna within a tow is uniform
- Otter board angle of attack is constant during a tow
- Ground cables are straight along their entire length
- Seabed contact does not change within a tow
- The effect of towing speed on seabed contact is accommodated by dt

Parameterizing the model

Each gear component (e.g. otter boards, sweep, cables, etc.) requires:

Contact patch	*empirically derived from observer data and other sources*
Contact index	*categorically specified by gear type*
Sensitivity index	*calculated from VA matrices*

Applying the SASI model spatially

The model represents a *quality-adjusted* area of seabed impacted by NE gears per spatial unit (e.g. tms, 5k grid)

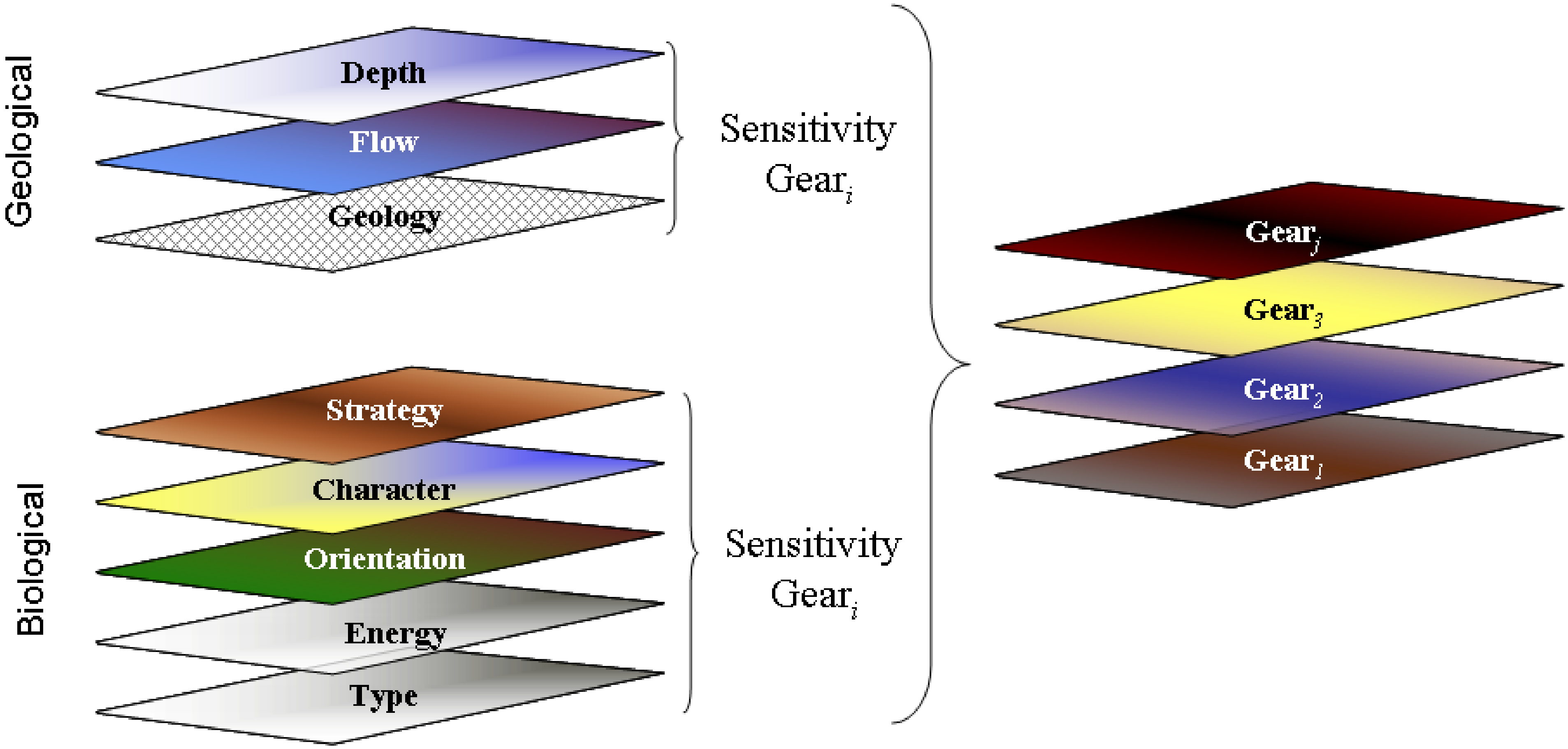
The Sensitivity Index (e.g., S_o, S_c, S_s), derived from the VA matrices, is specific to a combination of gear type/habitat/energy and applies uniformly across gear components

Spatial unit data

Each spatial unit must contain data summarizing:

- Impacting actions
  - Fishing effort
  - Energy
    - Depth
    - Flow (CSS)
- Impacted surface
  - Substrate
  - Biota
  - Prey
  - Deep Sea Corals

Applying the SASI model spatially

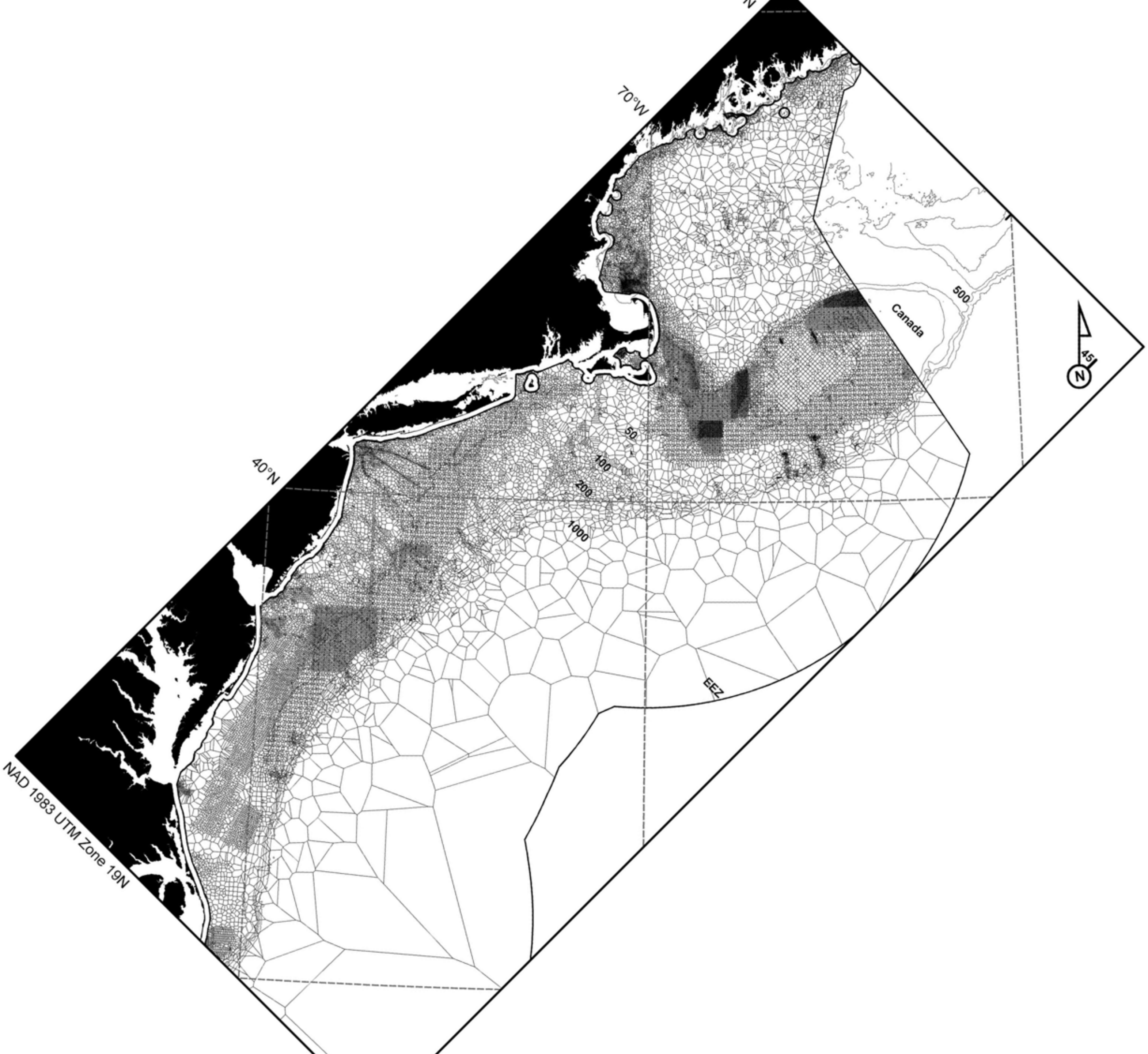


Defining spatial units

PDT is experimenting with different spatial units

Focus on Vorinoi tessellations:

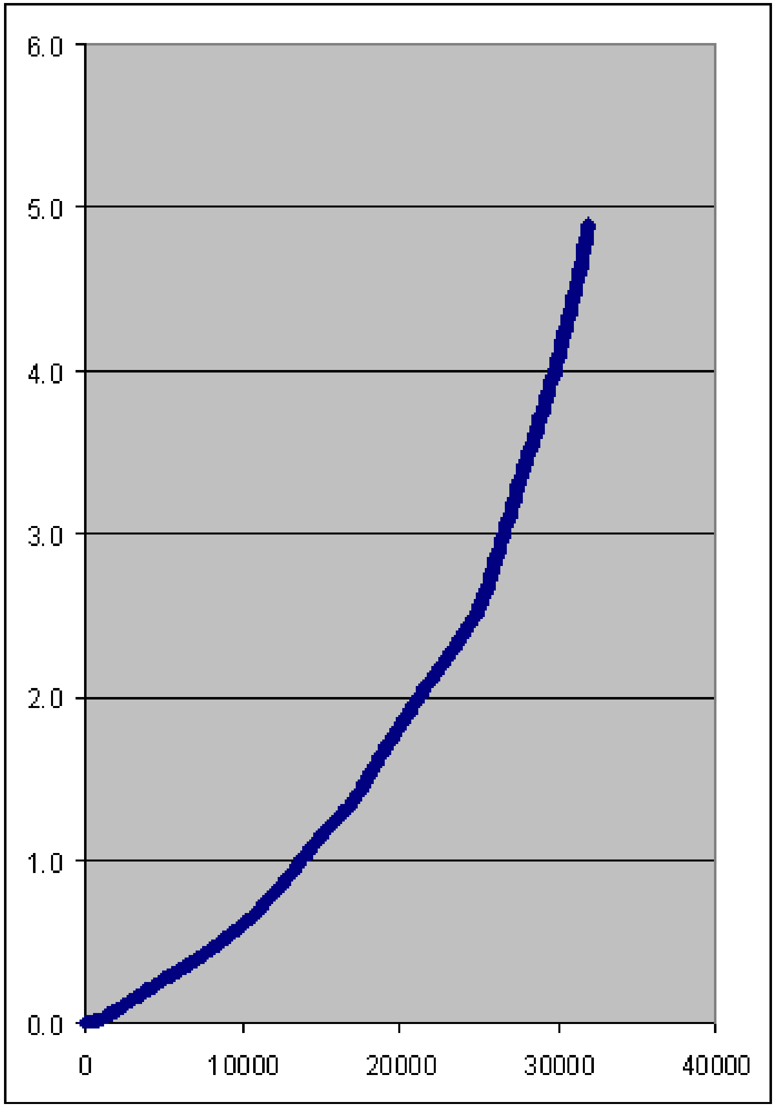
Vorinoi tessellations allow the size of the unit area to vary in proportion to the denisty of data available, producing irregular shaped polygons of varying sizes



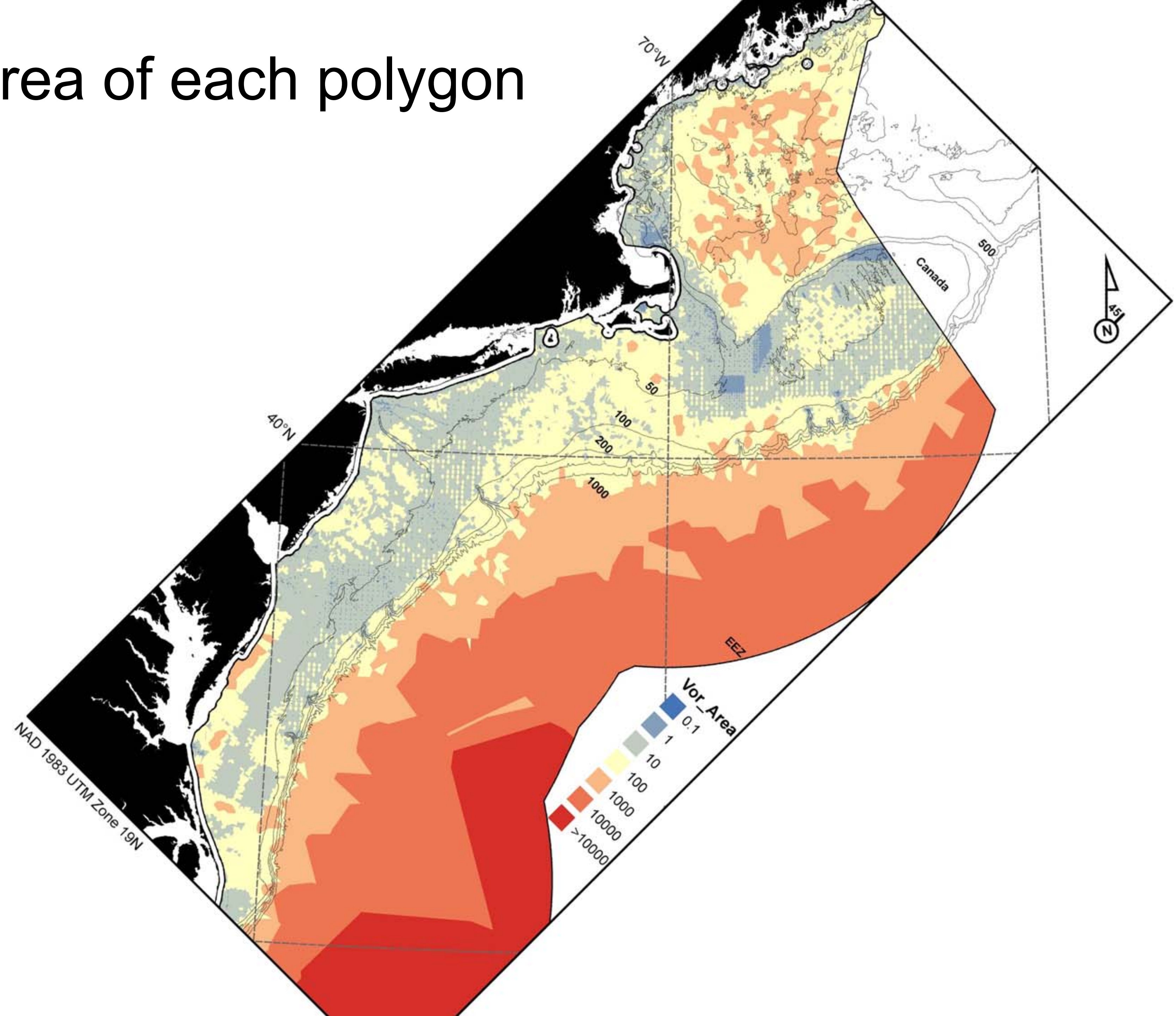
70°W
40°N
Canada
500
50
100
200
1000
EEZ
N
45
NAD 1983 UTM Zone 19N

Voronoi tesselation

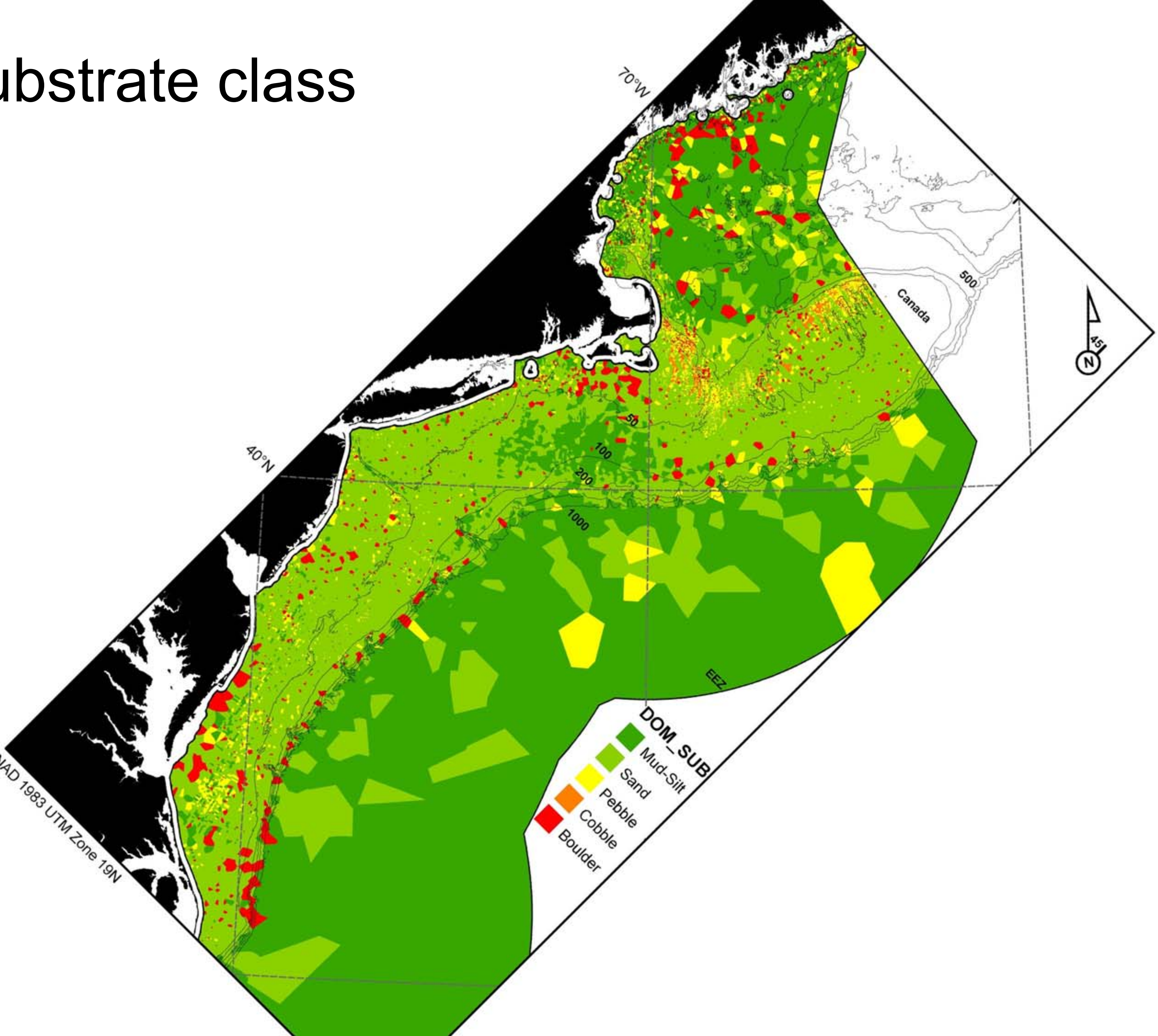
- 42,378 area units
- Most (~30,000) smaller than 3km^2
- Setting minimum size will reduce number of units and increase usability

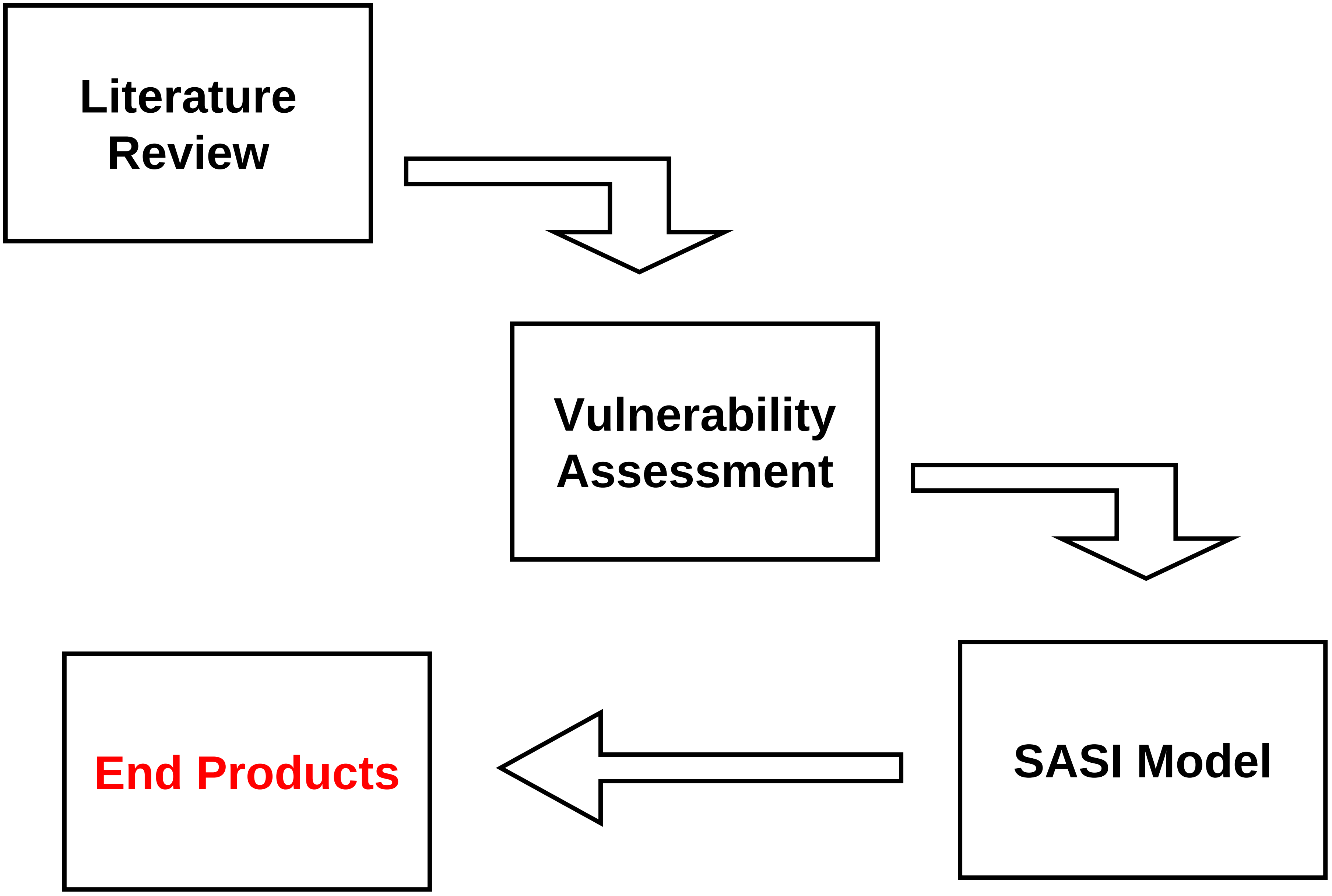


Area of each polygon



Substrate class




Literature Review
Vulnerability Assessment
SASI Model
End Products

End products

1. Matrices summarizing the hypothetical *sensitivity* of habitat components to fishing gears
2. Maps depicting the realized *vulnerability* of habitat area units to fishing gears, as measured by quality-adjusted m^2 and summed across all gears fishing in each area
3. Assessment of *adverse effects* based on pre-determined thresholds

Alternative development

- Maps and matrices will provide the public, Ctte and Council an objective tool for assessing the level and spatial extent of adverse effects
- Allows Ctte to focus on appropriate areas for management

Alternative impacts analysis

Matrices and SASI allow PDT to quantify and visualize changes in quality-adjusted seabed impacts, enabling analysis of:

- Area-based fishing restrictions *(mapping hypothetical or re-directed fishing effort)*
- Gear modifications *(changing SASI contact and sensitivity indices)*

Future EIS impacts analysis

This approach creates an objective, iterative model with a set of consistent metrics for analyzing and comparing adverse impacts to habitat across:

- All FMP documents
- Each FMP's Amendment and Framework documents