MERGING MODELING AND MAPPING: The Integration of Ecosystem-based Models and Interactive Data Viewers for Improved Aquaculture Decision Making

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Marine Aquaculture Site Selection

Overview

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- Marine aquaculture modeling can assess production potential, culture optimization (gear configuration, stocking density) and environmental effects

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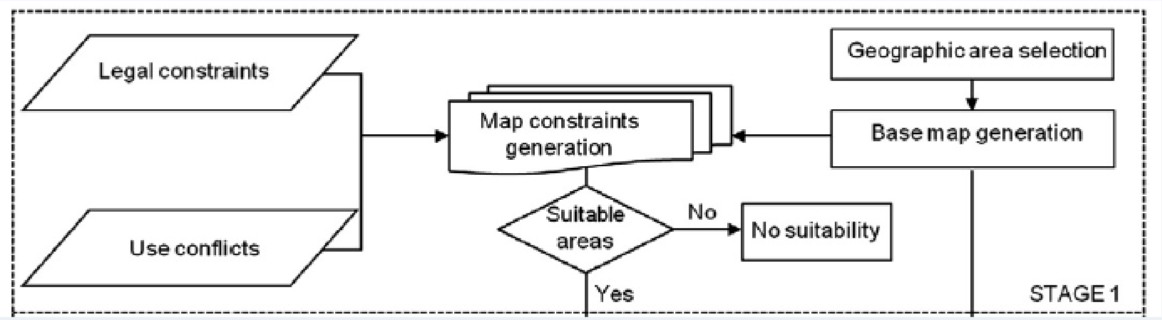
Overview

- Integrated, **mapping** + **modeling** allows users to simultaneously address social, environmental, economic factors towards an improved decision-making process

Considerations for Selecting Aquaculture Sites



Stage 1 - analysis of:

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b) **use conflicts**

Silva et al. 2011 . *Aquaculture.* 318: 444-457.

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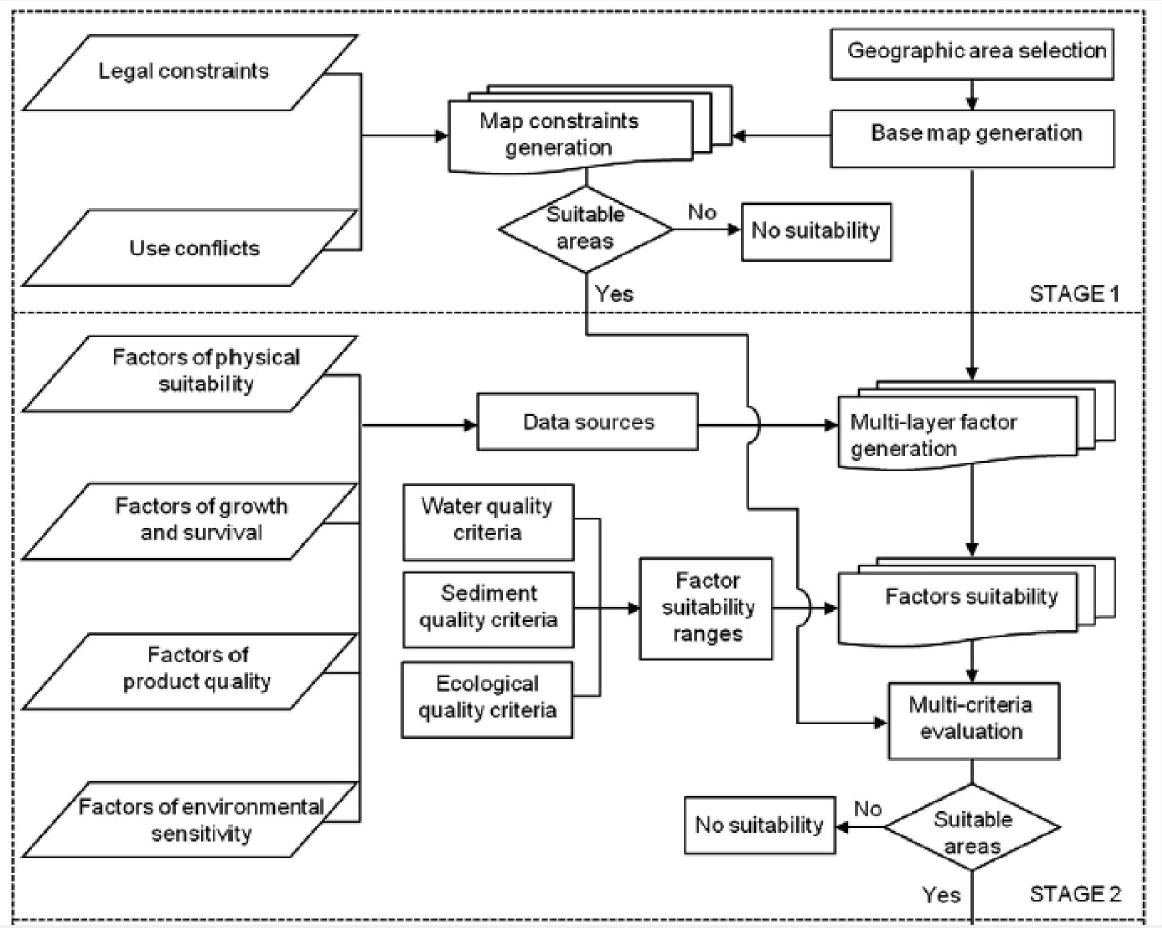

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Stage 2 - evaluation of:

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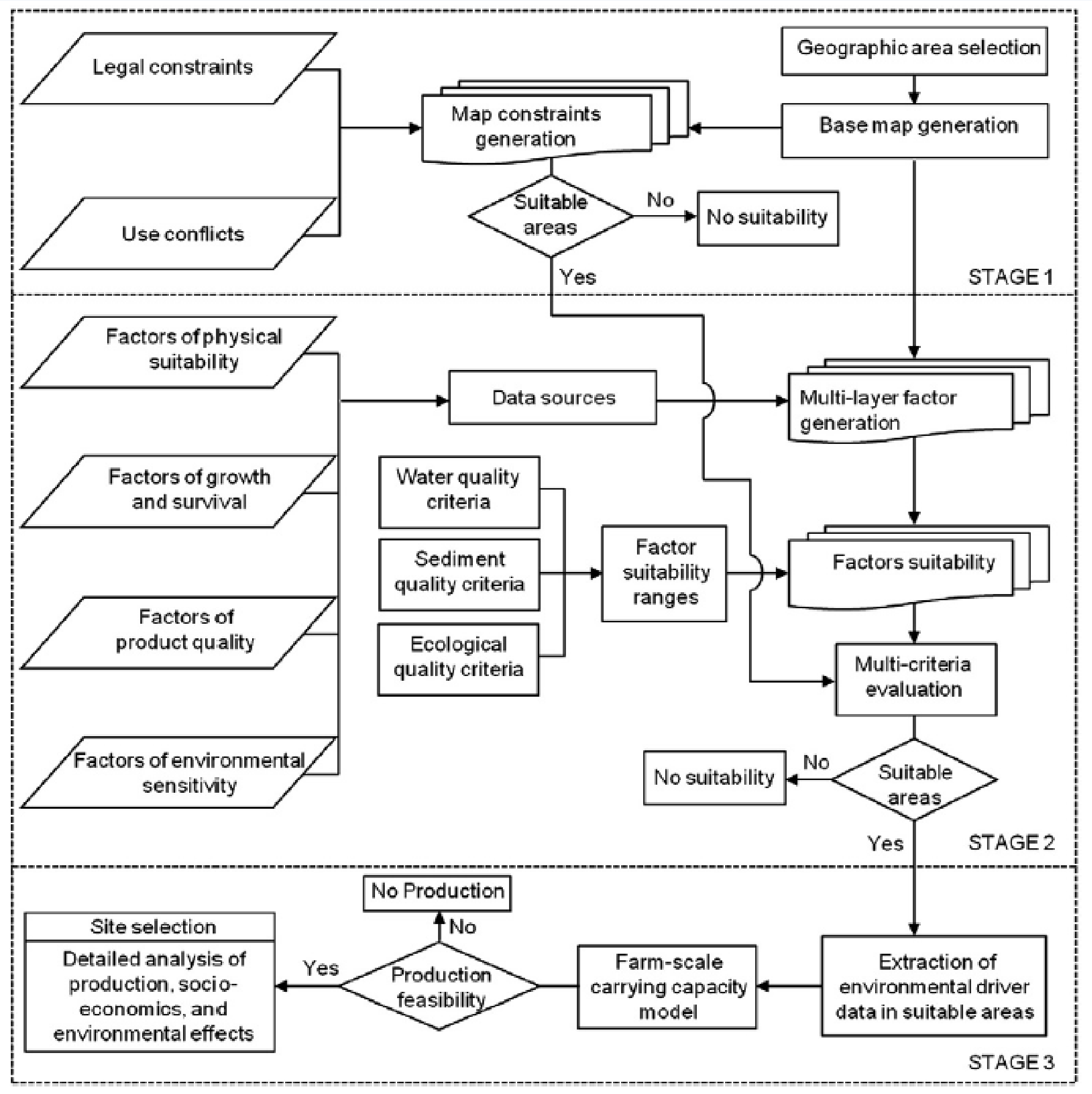

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Stage 2 - evaluation of:

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Stage 3 - analysis of:

a) production
b) socio-economic outputs
c) environmental effects

Why Merge Mapping & Modeling for Site Selection?

- **Growers** need production info to make decision about site
- **Regulators** have responsibility to prevent adverse impacts to habitat, species, and avoid use conflicts, provide this information to growers

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- Responsible growth: expand into areas without existing conflicts that are best suited for shellfish production

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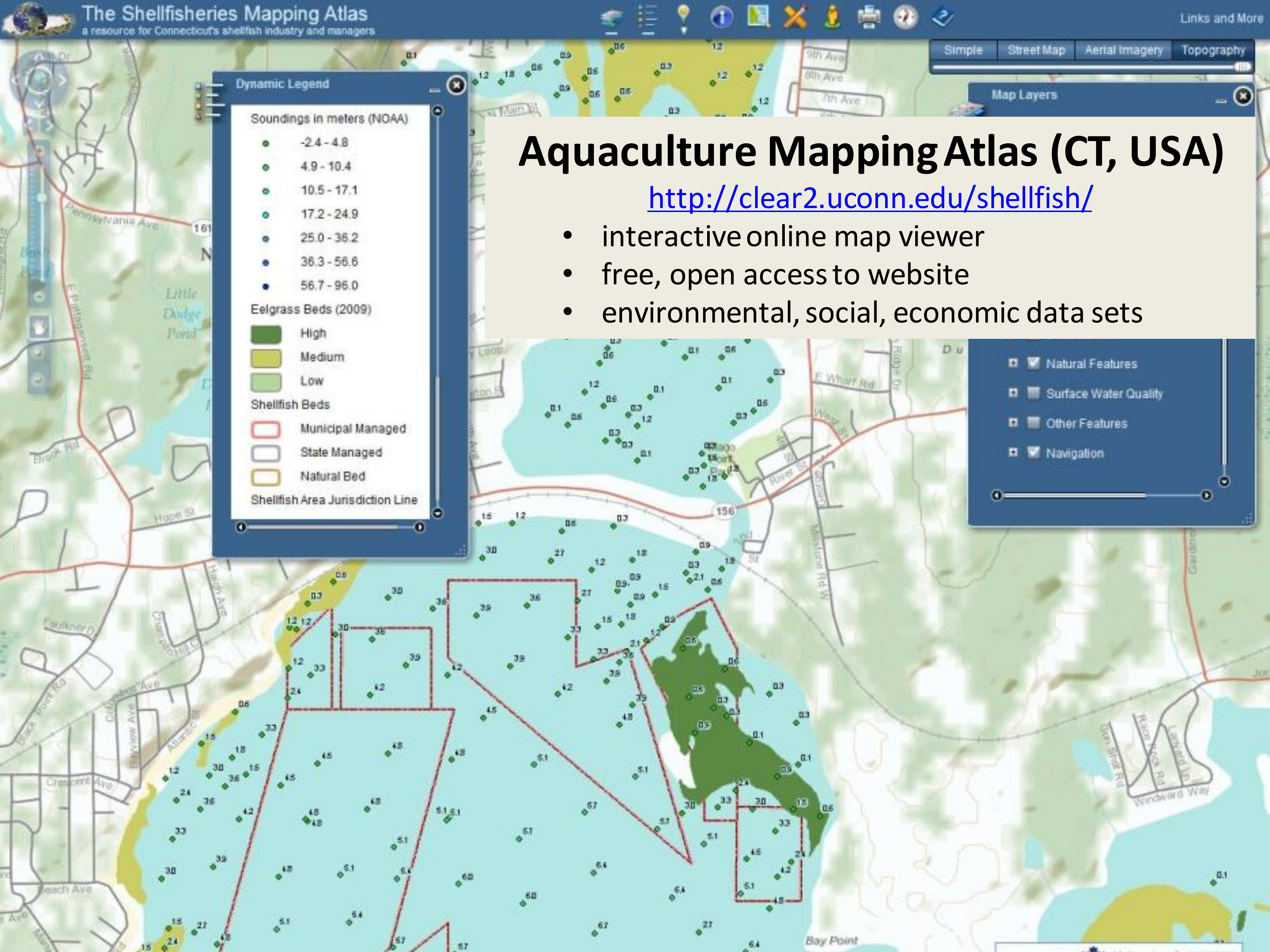
Our primary objective is to demonstrate that the integration of mapping and modeling tools can better inform the site selection process for marine aquaculture

/production/economics of cultured shellfish

- Smart Growth: expand into areas without existing conflicts that are best suited for shellfish production

Merging Mapping and Modeling

- **Mapping Tools**
  - Aquaculture Mapping Atlas http://clear2.uconn.edu/shellfish/
  - Shellfish iMap http://gis.co.suffolk.ny.us/shellfish/index.html
  - Hawaii Coastal Use Viewer http://www.mpa.gov/dataanalysis/hi_coastal_use/viewer/
- **Modeling tools**
  - Farm Aquaculture Resource Management (FARM) Model http://farmscale.org
  - ShellSIM http://www.shellsim.com/
- **Integrated Tools**
  - MARGIS http://www.marcon.ie/website/html/margis.htm (Ireland)
  - ShellGIS (under development, U.S.; abstract in JSR)
  - Akvavis: http://insitu.cmr.no/akvavis/akvavis.html (Norway)



Aquaculture Mapping Atlas (CT, USA)

http://clear2.uconn.edu/shellfish/

- interactive online map viewer
- free, open access to website
- environmental, social, economic data sets

Shellfish iMap (NY, USA)

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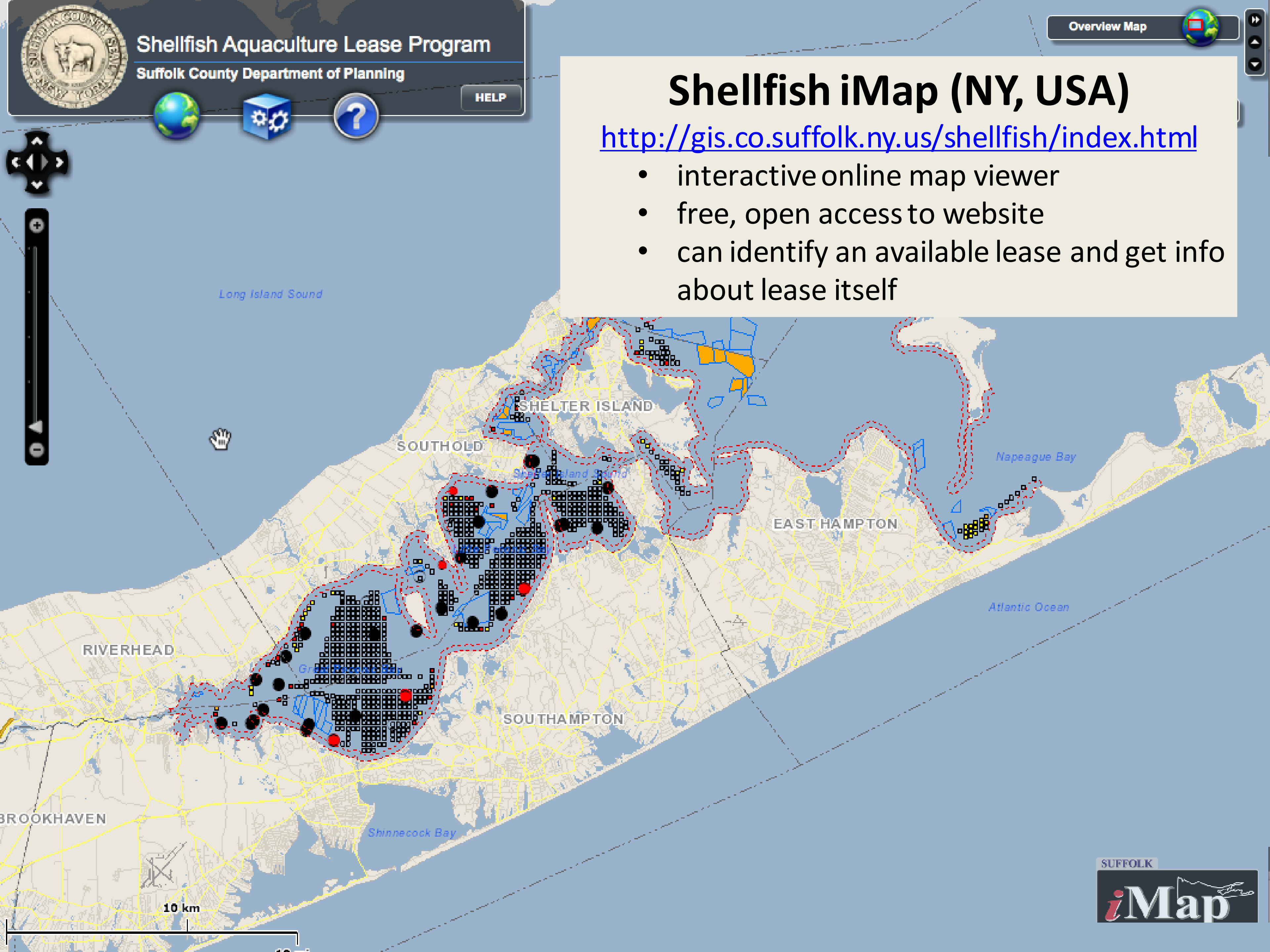
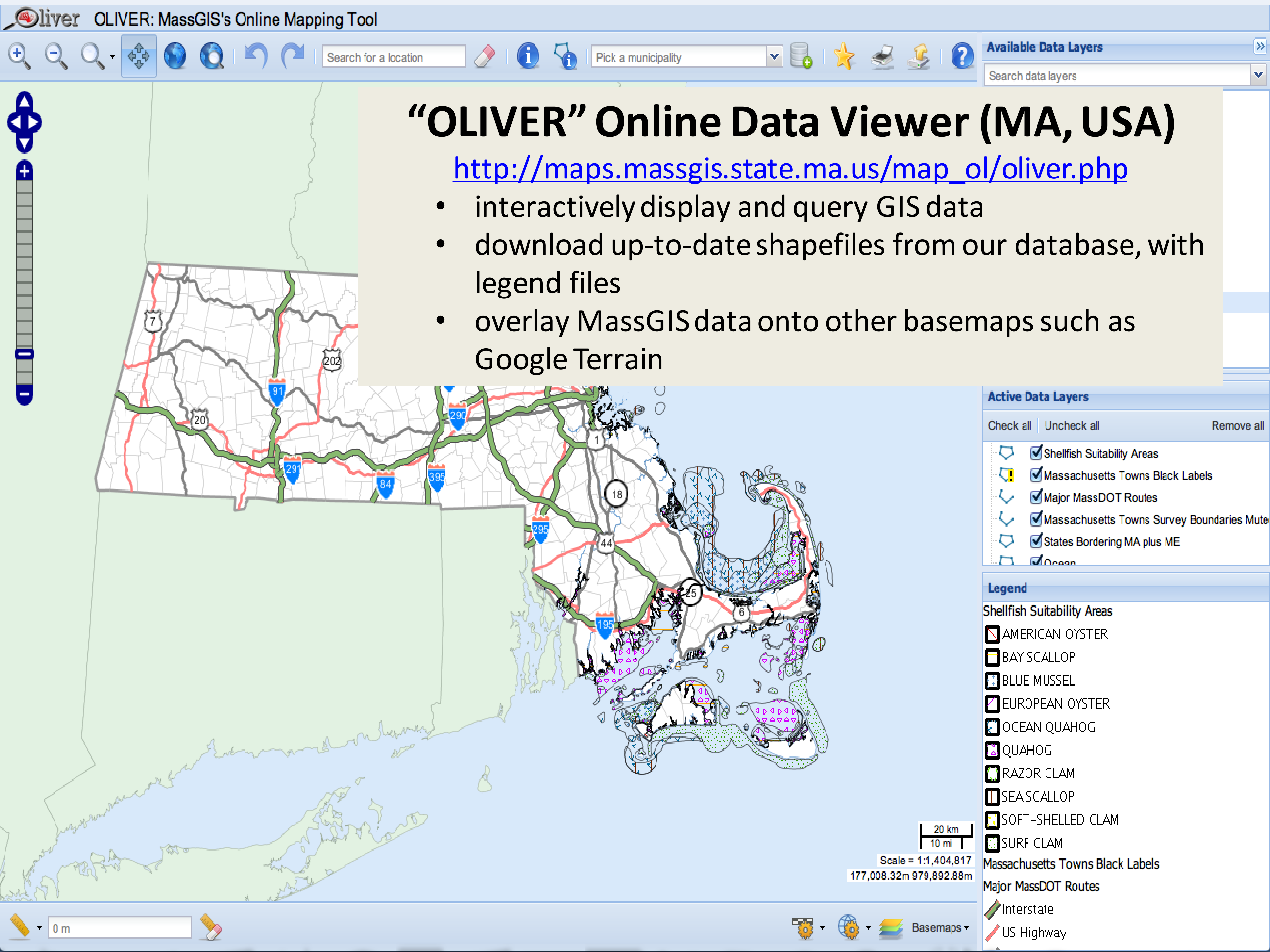
- interactive online map viewer
- free, open access to website
- can identify an available lease and get info about lease itself



"OLIVER" Online Data Viewer (MA, USA)

http://maps.massgis.state.ma.us/map_ol/oliver.php

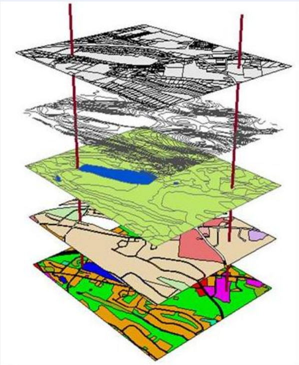
- interactively display and query GIS data
- download up-to-date shapefiles from our database, with legend files
- overlay MassGIS data onto other basemaps such as Google Terrain



Demonstration Project

- For this demonstration we have integrated the **Aquaculture Mapping Atlas** and the **FARM Model** to assess production potential of oyster farms
  - Step 1: Use mapping tool to identify suitable areas (without use conflicts; adverse environmental interactions)
  - Step 2: Use model simulation to identify production potential (will animals grow?, growth rate?, compare sites)

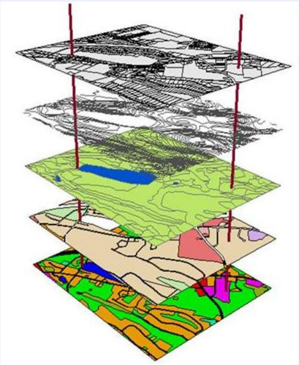
(Data from 2008, Station 09, CTDEEP monitoring Program – from: Matt Lyman)



Step 1: Mapping Objective

Overlay GIS layers of legal, contaminant, competing uses, and other restrictions to eliminate unsuitable areas, identify areas suitable to aquaculture

ECONOMIC	SOCIAL	ENVIRONMENTAL
Site characteristics relevant to production, gear type, configuration	Historical, current and potential future uses	Non-production site characteristics; potential for interaction, adverse effects



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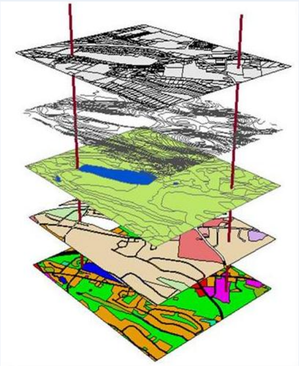

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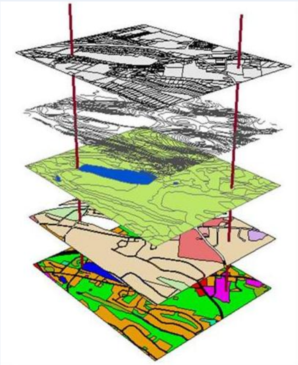

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Aquaculture Mapping Atlas: GIS Layers

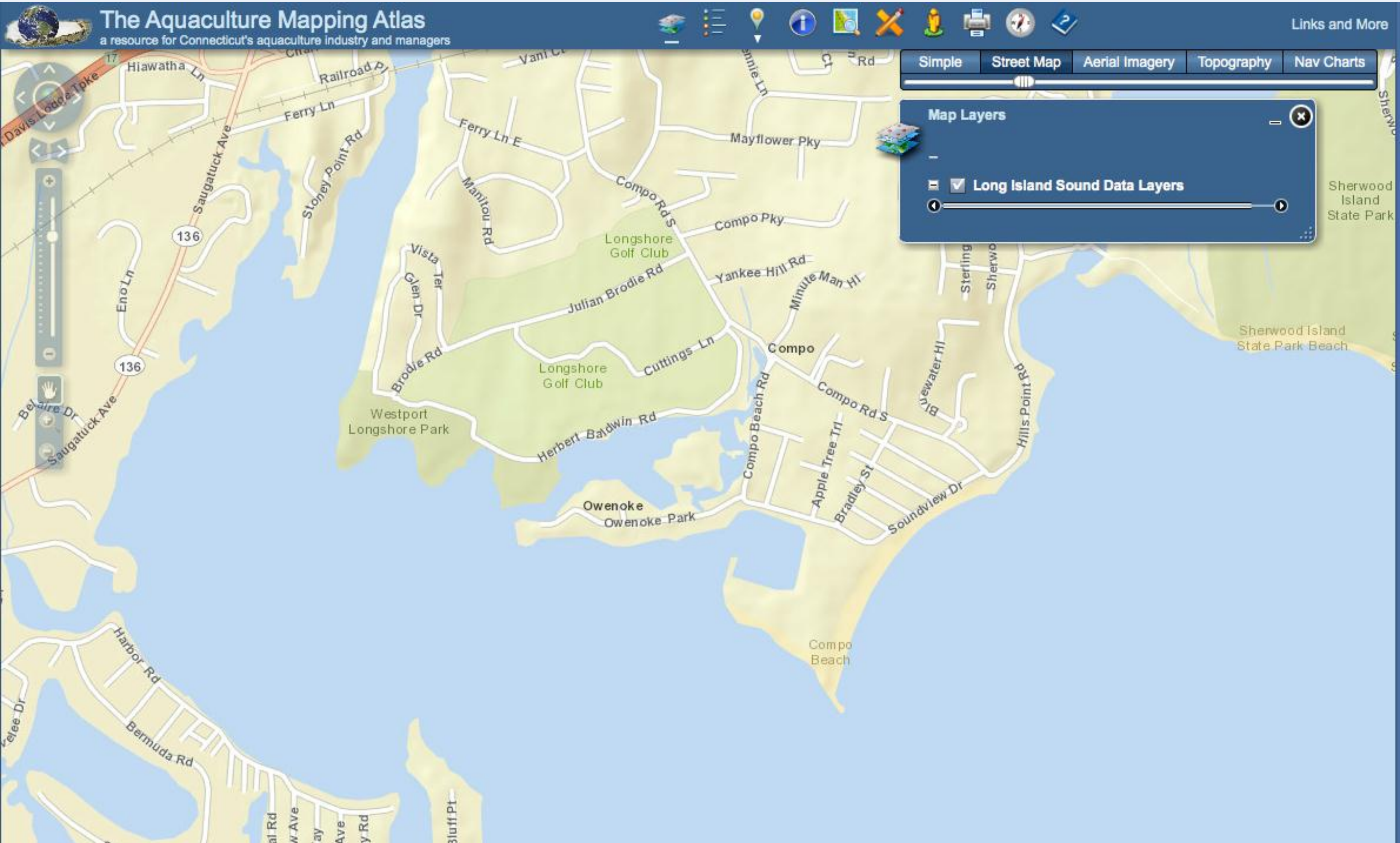
- Use mapper tool for area of interest to look at successive map layers to eliminate unsuitable areas:

  1) **Street map**: locate, identify area of interest
  2) **Navigation layers**: channel areas + buffer, bathymetry, cables and buoys
  3) **Shellfish Beds**: location of municipal/state/natural beds
  4) **Shellfish classification**: prohibited, conditional, approved
  5) **Environmental sensitivity index**: habitats, species, natural diversity
  6) **Marina location**: use conflicts

- Anticipated output: ‘suitable’ areas for potential aquaculture siting

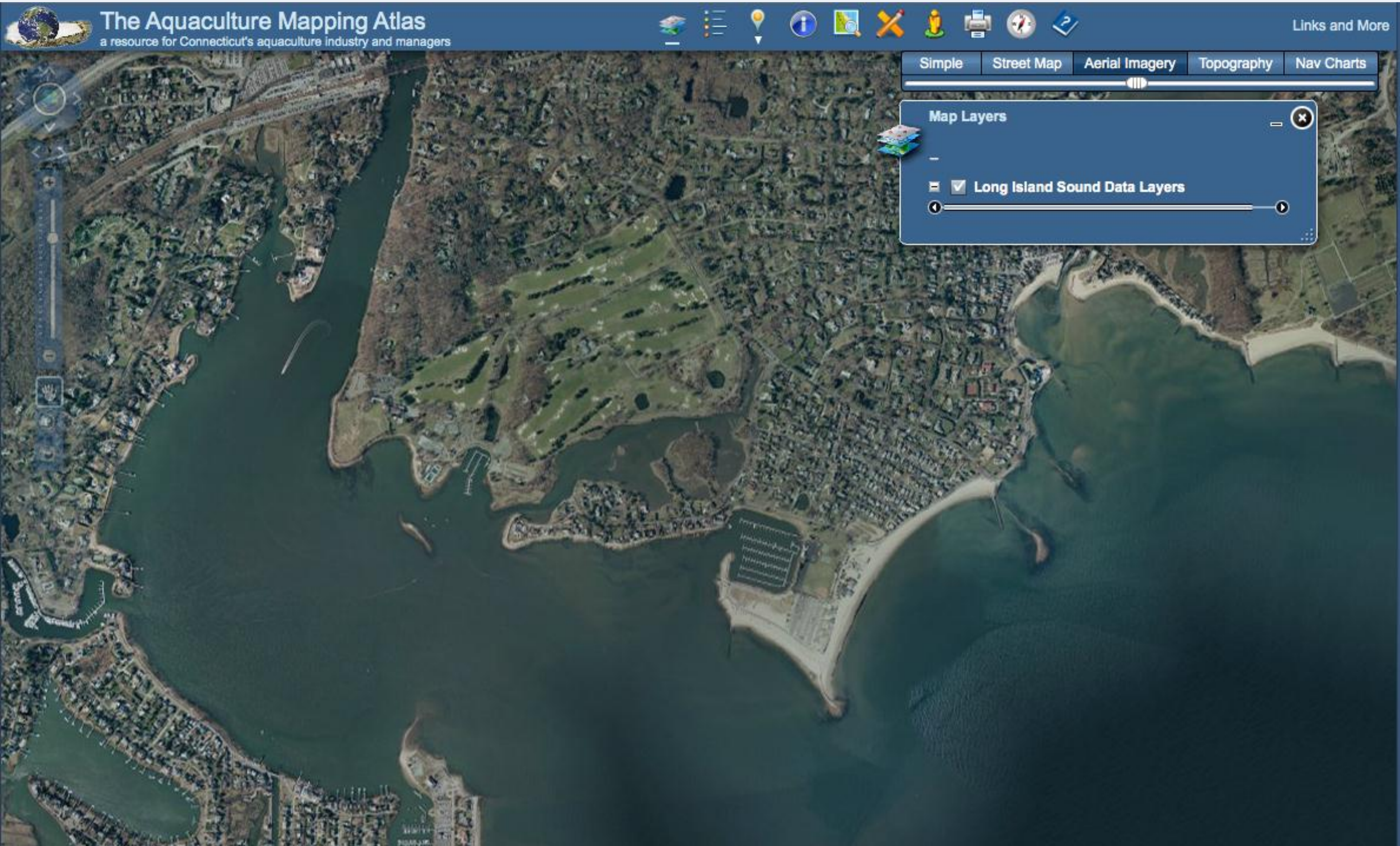
Aquaculture Mapping Atlas: GIS Layers

1) Street map: locate, identify area of interest



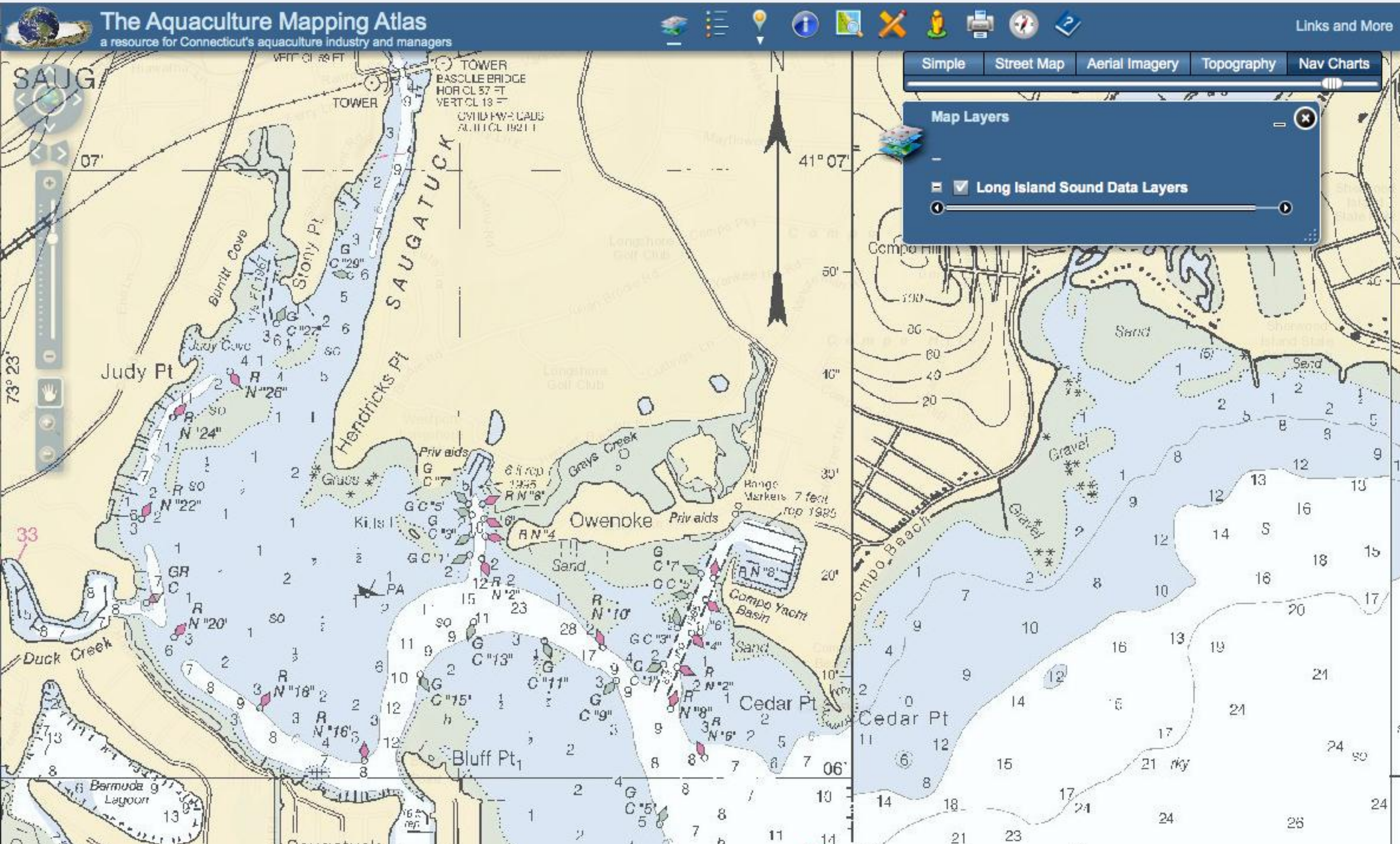
Aquaculture Mapping Atlas: GIS Layers

1) Imagery



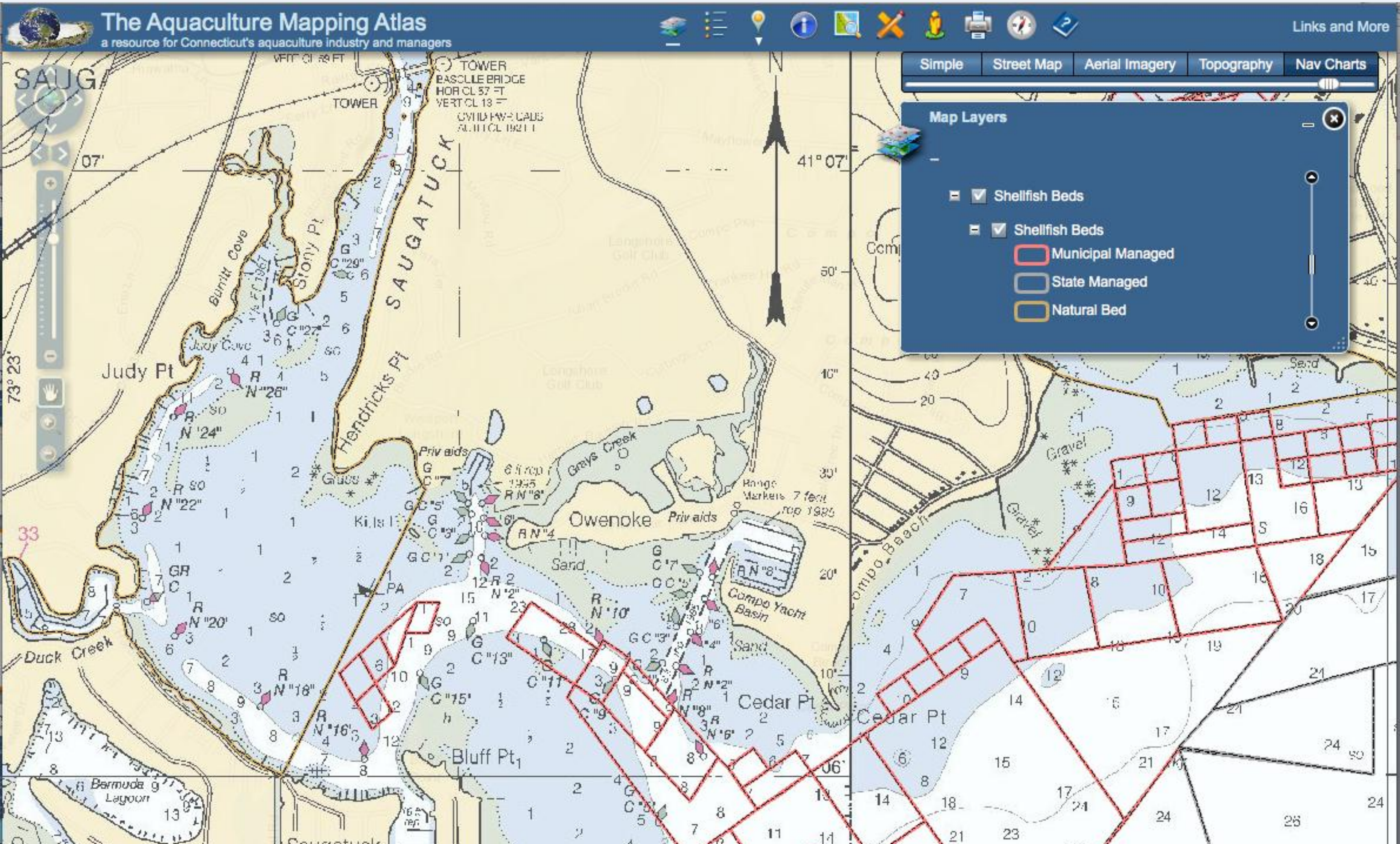
Aquaculture Mapping Atlas: GIS Layers

2) Navigation layers: channel + buffer, bathymetry, cables, buoys



Aquaculture Mapping Atlas: GIS Layers

3) Shellfish Beds: location of municipal/state/natural beds



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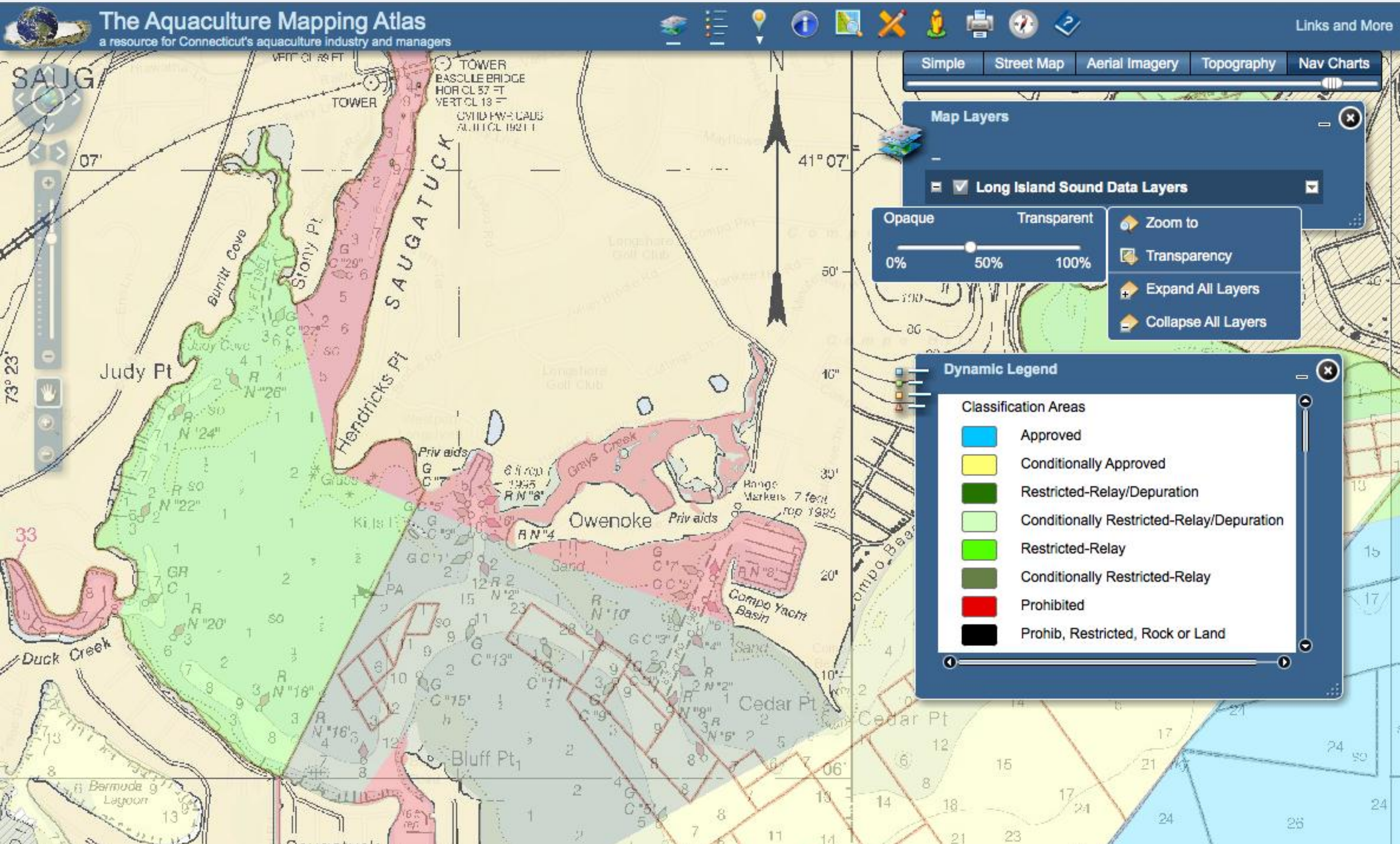
4) Shellfish classification: prohibited, conditional, approved



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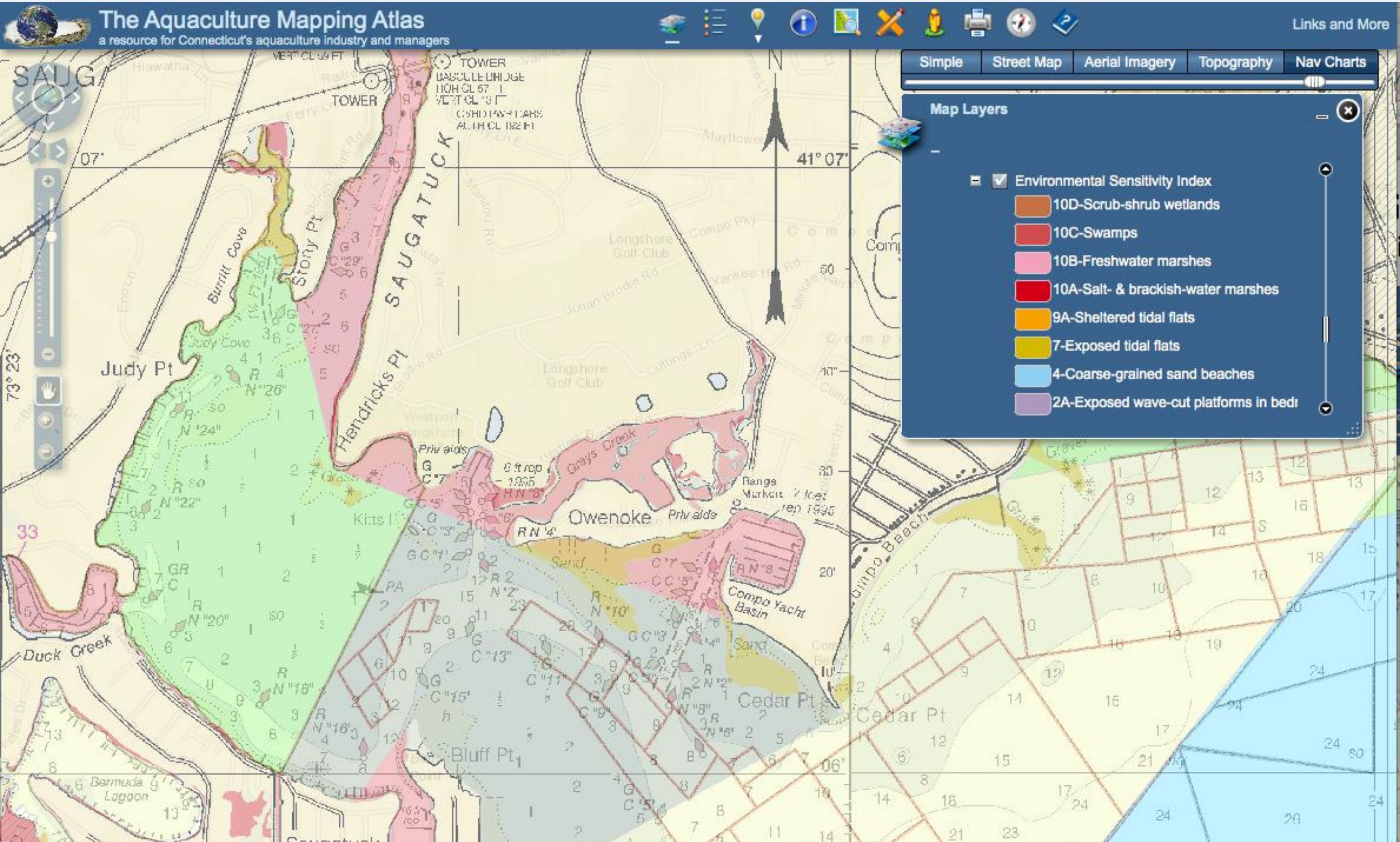
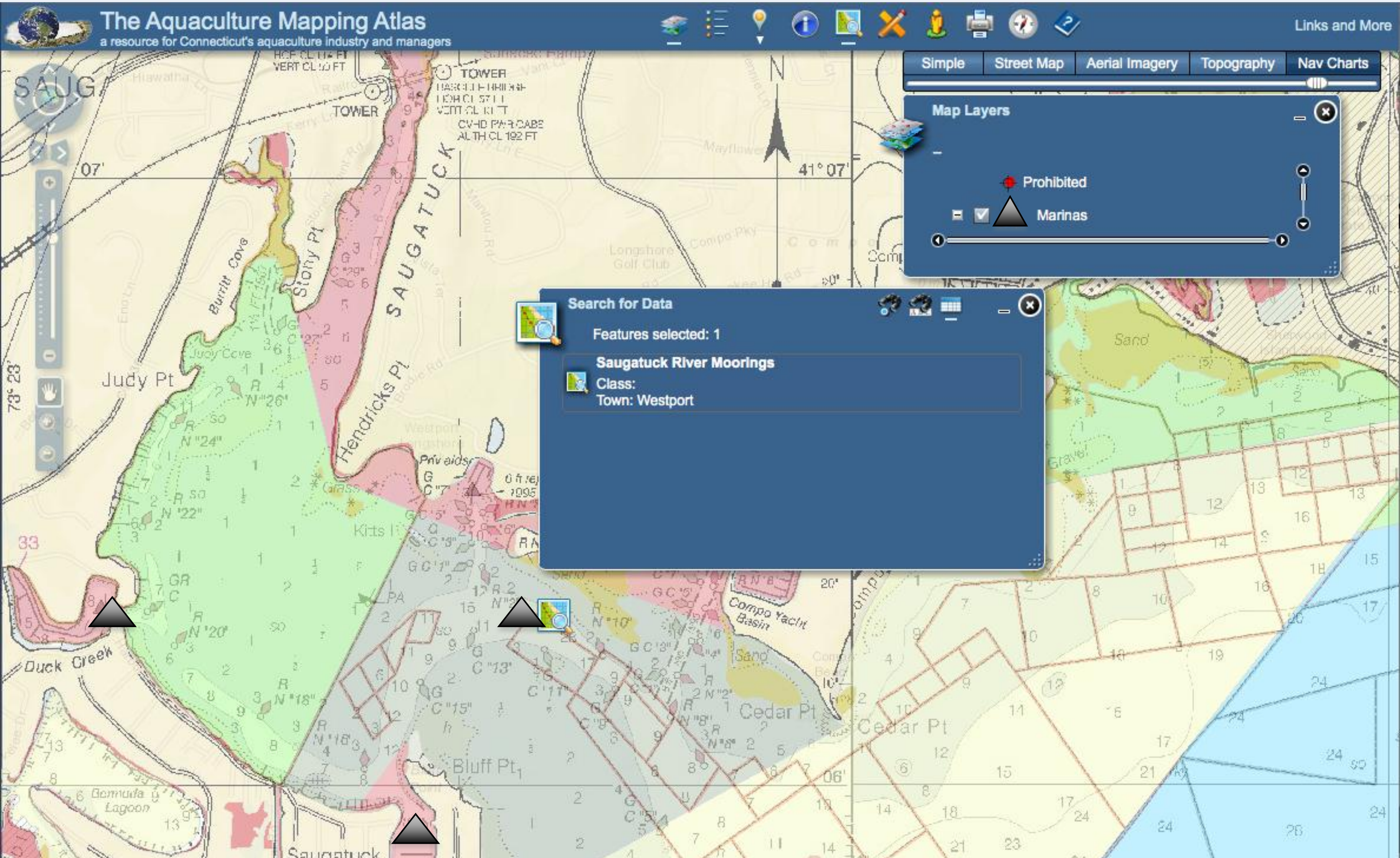
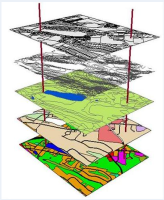
5) Environmental sensitivity index: habitats, species, diversity



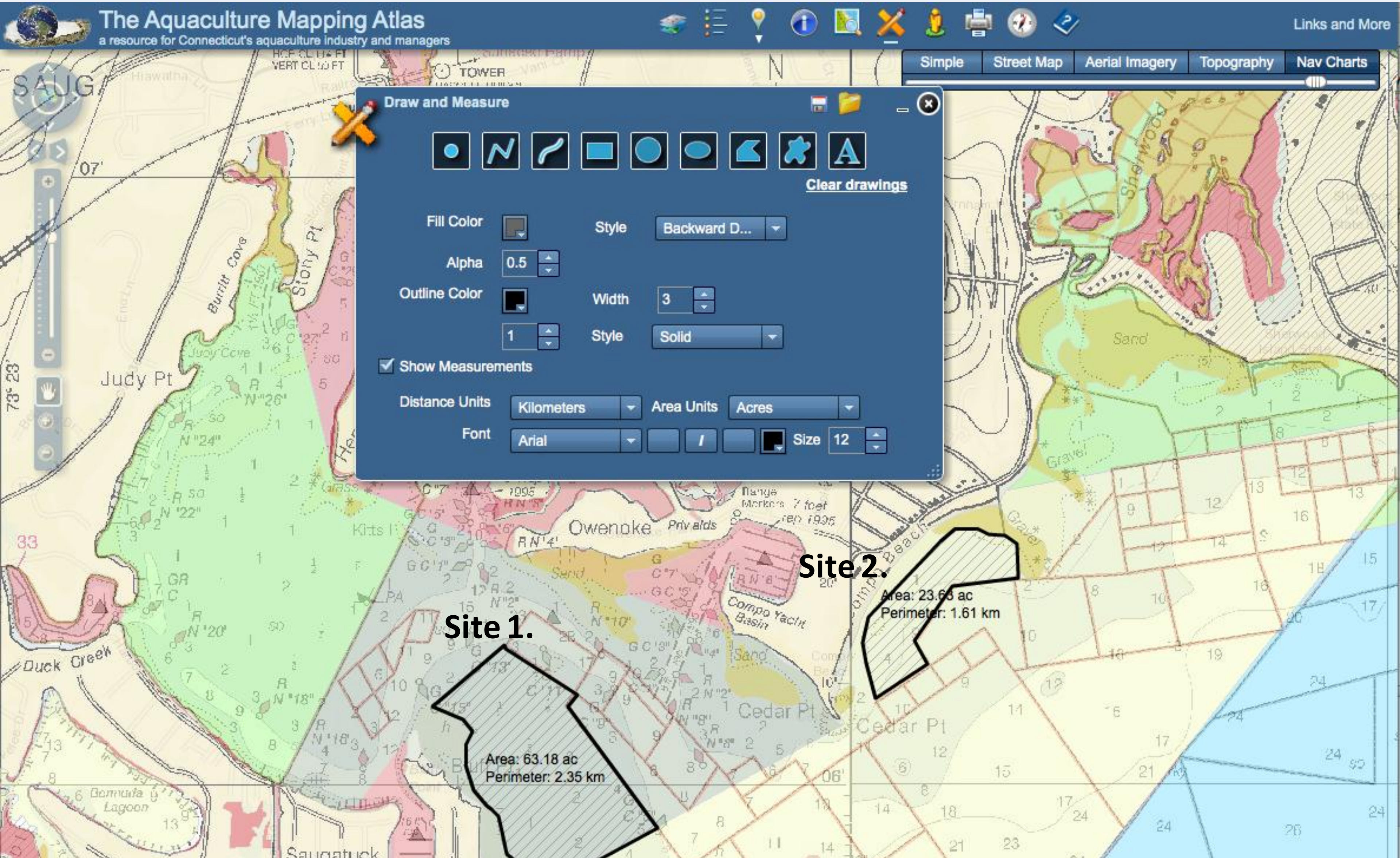
Aquaculture Mapping Atlas: GIS Layers

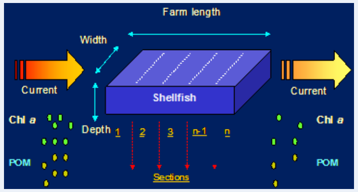
6) Marina location: use conflicts



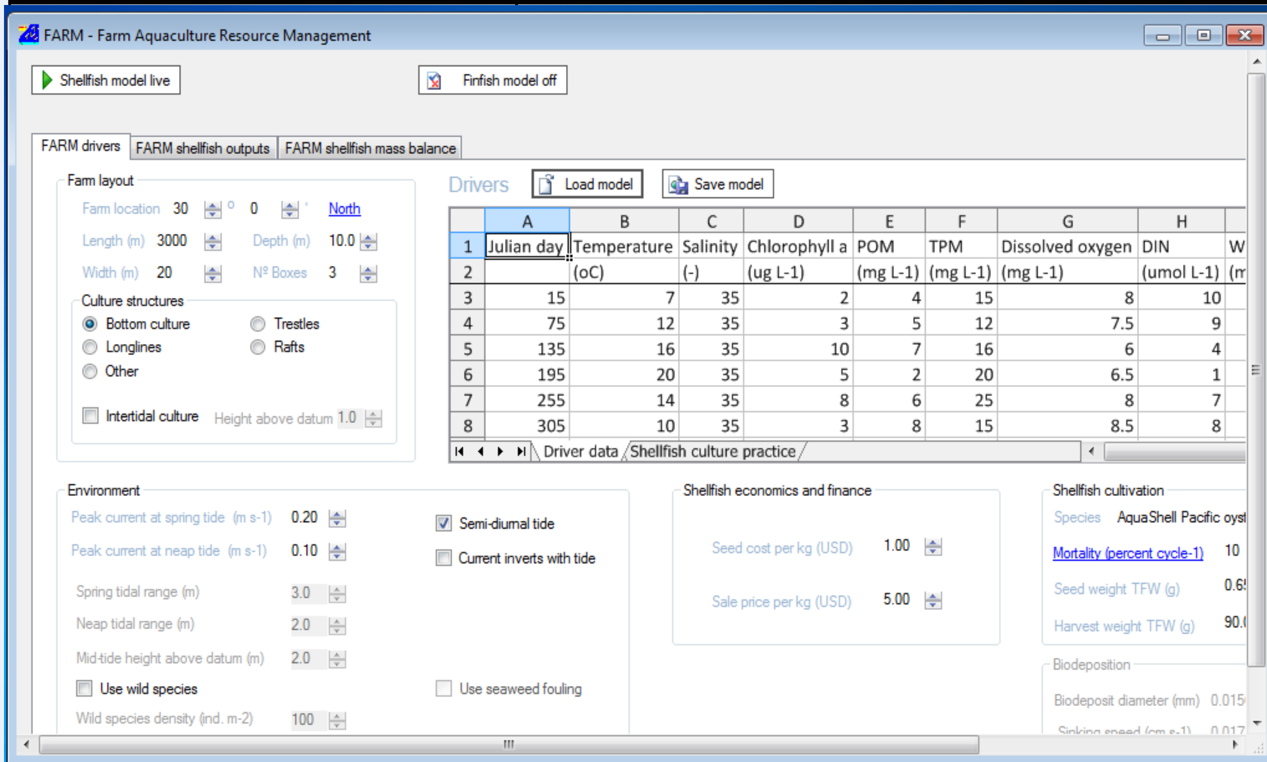


Step 1: Output
"Suitable" sites based on mapping





Step 2: Modeling Objective

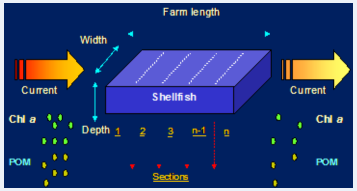
MODEL INPUTS	MODEL OUTPUTS
	**Weight (g)** **Length (cm)** Harvest (tons) Chlorophyll POM TPM Dissolved Oxygen Total physical product (TPP) Average physical product Total revenue (TR) Total cost (TC) Profit **Time to market size (years)**

For this demonstration, the FARM model evaluates:

–Will oysters grow at the “suitable” sites?

–If so, how quickly will they grow to market size?

–How do sites compare to each other?

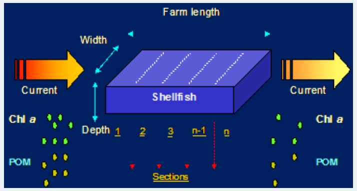


Step 2 Output: Suitable sites based on modeling

- Model assesses data from two sites to result in a time to market size for each site

- Assumptions:
  - Seed size = 5mm
  - Market size = 76mm
  - Bottom culture

- Site 1: All parameters equal except **measured chl a**
- Site 2: All parameters equal except **50% measured chl a**



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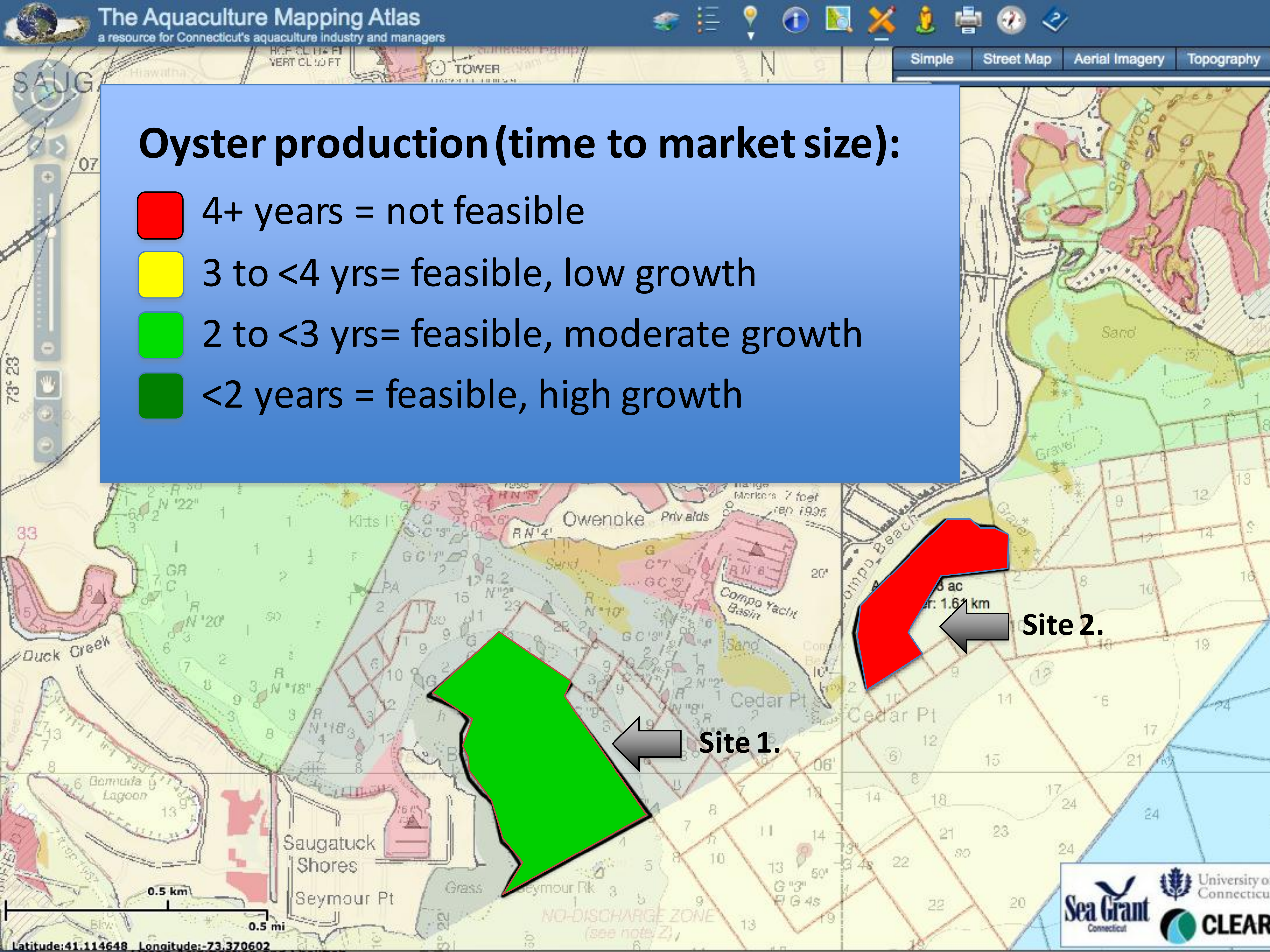
Suitable sites based on modeling

- Data transformed into a visual (chromatic) output so that it can be overlayed with output from Step 1 Mapping Objective.

Oyster production (time to market size) :

- 4+ years = not feasible
- 3 to <4 yrs= feasible, low growth
- 2 to <3 yrs= feasible, moderate growth
- <2 years = feasible, high growth

Time frames highly dependent on water temperature and husbandry method (surface vs. bottom culture)


The Aquaculture Mapping Atlas
a resource for Connecticut's aquaculture industry and managers
Simple
Street Map
Aerial Imagery
Topography
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Site 1.
Owenoke
Compo Yacht Basin
Cedar Pt
Duck Creek
Bermuda Lagoon
Saugatuck Shores
Seymour Pt
NO-DISCHARGE ZONE
0.5 km
0.5 mi
Latitude:41.114648 Longitude:-73.370602
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- Mapping helps user identify potential sites by selectively eliminating sites with use conflicts or where activity would result in adverse environmental interactions
- Modeling can answer questions about:
  - Potential production (e.g. time to harvest)
  - Culture optimization (e.g. gear configuration, stocking density)
  - Carrying capacity (if ecosystem models are included)
  - Environmental effects - potential nutrient removal by harvested shellfish
  - Economic impacts to farmers (e.g. nutrient trading program) and to larger economy (if economic impact analysis included)

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- Modeling tools can be integrated where mapping capabilities already exist
- Compare notes with others who are using marine aquaculture site selection tools

Acknowledgments

- NOAA Aquaculture Program, Michael Rubino and Michael Rust
- NOAA Office of Aquaculture Project # NS-COAST-001-Bricker
- Sally Cogan and Claire Gavin, Clean Up Stonington Harbor (CUSH)
- Dick Harris, Nikki Cantatore and Josh Cooper, HarborWatch/RiverWatch at Earthplace
- Robert Alix and Werner Schreiner, NOAA
- Joao Ferreira, FARM model originator

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