



Spatial Data Needs for the Development and Management of Open Ocean Aquaculture (OOA)

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Coastal GeoTools '09, March 2-5, 2009

Objectives

- 1. Prove the Concept
 - *Is it possible to make indicative estimates of open ocean aquaculture potential using readily available data sets with global coverage?*
- 2. Encourage developing countries to explore their own OOA potential
- 3. GeoTools '09
 - OOA as a new, friendly user of the ocean environment
 - Data needs as the vehicle



Food and Agriculture
Organization of the United
Nations

Overview

- Open Ocean Aquaculture in a Seashell
- Data Needs for the Development and Management of Open Ocean Aquaculture
- Data Put to Use: Estimates of Open Ocean Aquaculture Potential
- Current Speed as a Data Gap
- Data Sources
- Conclusions

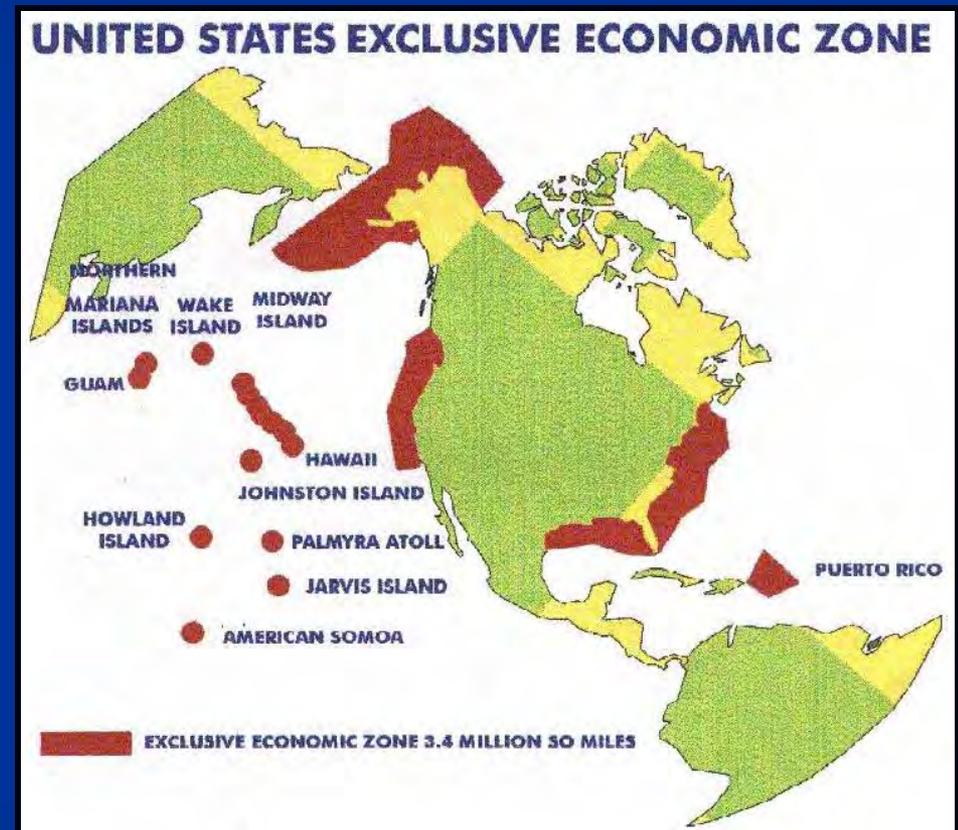
Part 1. Open Ocean Aquaculture in a Seashell

- Aquaculture by environment
 - Freshwater
 - Brackishwater
 - Marine
 - Inshore
 - Offshore



Rationale for Open Ocean Aquaculture in the US

- Environmental concerns inshore
 - Impacts of aquaculture on the environment
 - Environmental impacts on aquaculture
- Seafood trade deficit > \$ 9 billion
- US ranks 14th in global marine aquaculture production, but...
- The US possess the world's largest EEZ area



Open Ocean Aquaculture Situation in the US

- Impeded by lack of
 - Enabling environment
 - National Offshore Aquaculture Act of 2007?
 - Technologies for offshore culture structures
- Potential
 - Where?
 - For which species?
 - How much?

Part 2. Data Needs for the Development and Management of Open Ocean Aquaculture



Ways to Consider Data Needs for Open Ocean Aquaculture

- Legal or administrative jurisdiction
- Location installations and functions
- Level of detail of the analysis
- Time frame
 - Development => Operations

Jurisdictions for Development



- Inshore and onshore: State waters, local government lands and private property
- Offshore: Federal waters in Exclusive Economic Zones; leased for aquaculture

Functions Dictating Data Needs

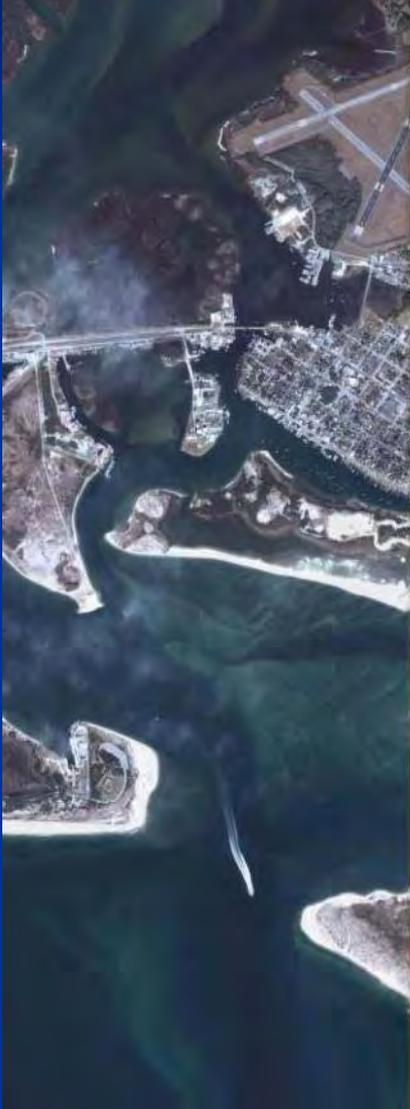
Onshore

- Onshore installation roles
 - Spawning and juvenile production facility for offshore grow out
 - Transit point for juvenile fish, fish feed and harvested fish
 - Servicing and maintenance base for the offshore installation



Criteria Dictating Data Needs

Onshore



- Proximity to:
 - Airports, roads, & railroads
 - Goods (fish "seed", fish feed, fuel)
 - Services (equipment maintenance, fish processors, transporters)
 - Skilled labor
 - Offshore grow-out facility
- Working & storage space, dock
- All-weather ocean access
- Coastal risk/vulnerability?

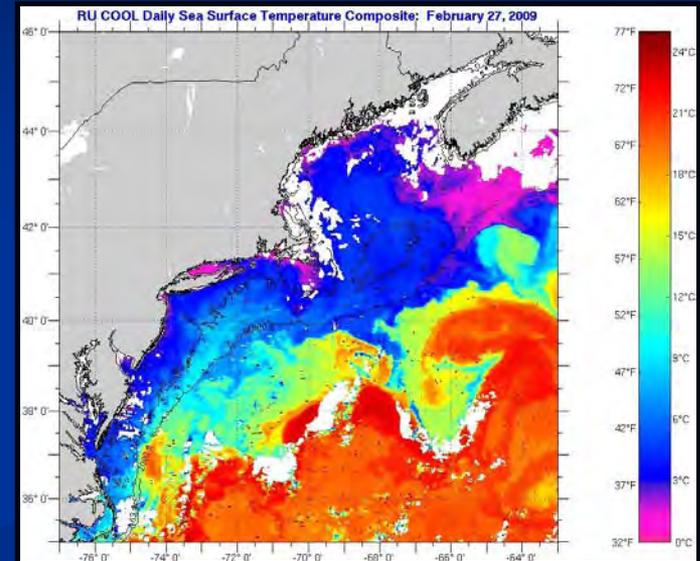
Criteria Dictating Data Needs Offshore

- Offshore installation
 - Healthy environment
 - Fast growth and high survival rate of cultured organisms
 - Safe environment
 - Physical security of culture structures (cages, longlines)



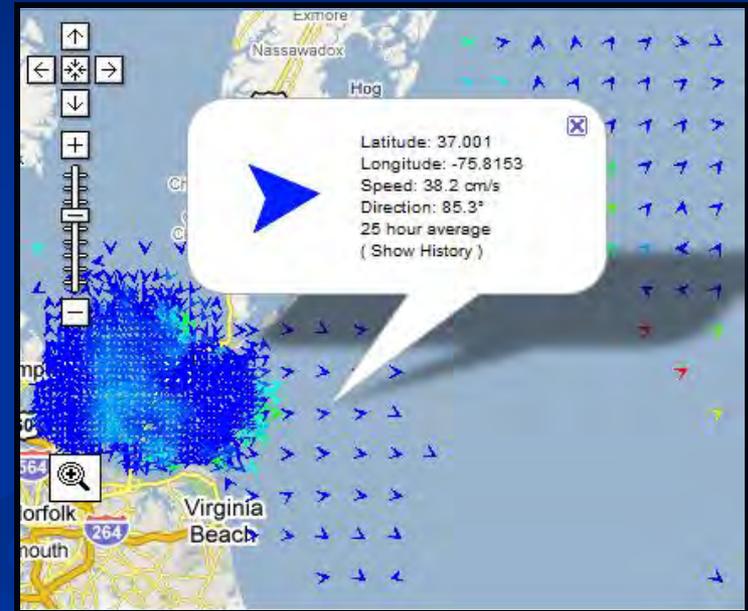
Data Needs Offshore – Cultured Animals and Plants

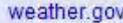
- Growth a/o well-being of cultured organisms
 - Temperature (affects feeding rates; growth)
 - Chlorophyll-a (filter feeders)
 - Nutrients (plants)
 - Current speed
 - Dissolved oxygen
 - Harmful algal blooms
 - Dead zones



Data Needs for Management (Daily Operations)

- Current speed (affects feed and waste dispersal; food availability of filter feeders)
- Current direction (affects area of waste deposition)
- Marine weather (access: seed and feed delivery, harvest and maintenance)
 - Storm, hurricane predictions
 - Wave height (affects support vessel operations; turbulence affects fish)
- Temperature Harmful algal blooms



 **National Weather Service** 
National Hurricane Center 

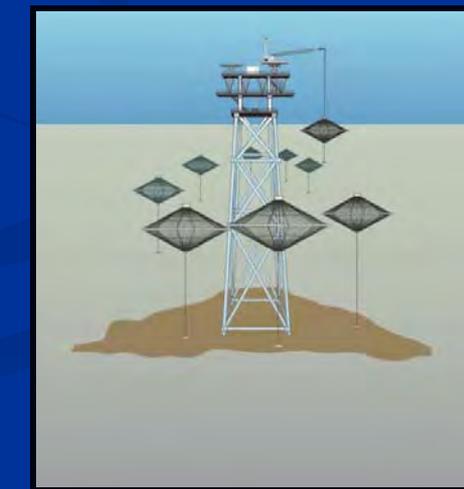
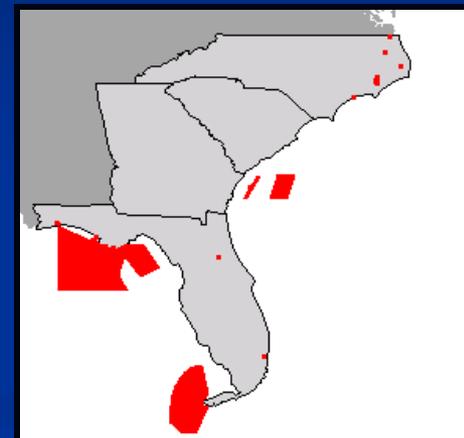
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Competing, Conflicting and Complementary Uses Offshore

- Living natural resources
 - Environmental concerns (ecosystem integrity, endangered species, critical habitats, MPAs)
- Other uses
 - Commercial and recreational fisheries
 - Navigation, minerals extraction
 - "No go" areas (military exercise zones)
- Shared infrastructure
 - Renewable energy
 - Oil drilling platforms



Data Needs for Development: Level of Analysis

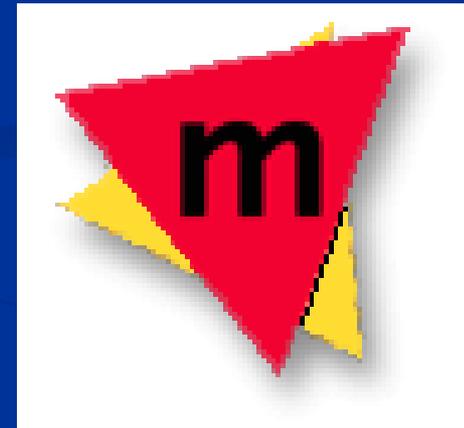
	Potential	Zoning	Siting
Scope	Comprehensive of entire AOI	Clusters within AOI	Focused on individual sites
Resolution	Low	Moderate	High
Results	Indicative; general	Directed; moderately detailed	Specific; detailed
Sponsoring entities	Researchers, Central government	Central and local governments	Private individuals and corporations
Data needs	Few; very basic	Many; diverse	All that are affordable!

Time scales relating to data needs

- Potential, siting and zoning
 - Long term data collections revealing central tendencies and dispersion
 - Diurnal, tidal and lunar cycles, seasonal, annual, inter-annual
 - Culture experience (e.g., temperature optima)
- Real time management of aquaculture operations
 - Up to the minute conditions
 - Short-term predictions (e.g., red tide)

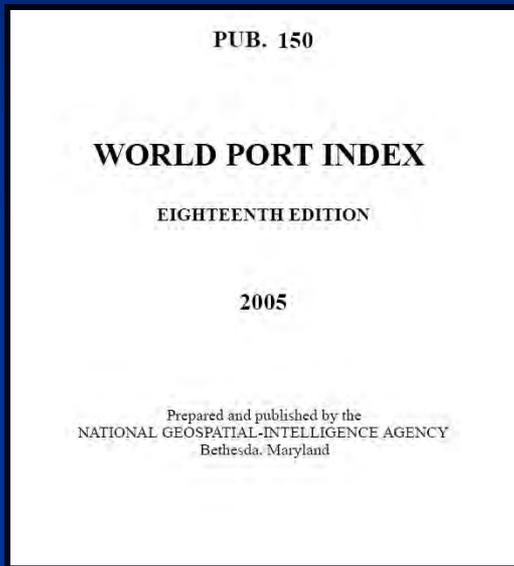
Tasks for GIS in Support of the Development and Management of OOA

- Estimate potential
 - Develop policy and plan
 - Stimulate commercial interest
- Zone and site
 - Regulate and monitor
- Manage operations in real time
 - Maximize production
 - Minimize risks



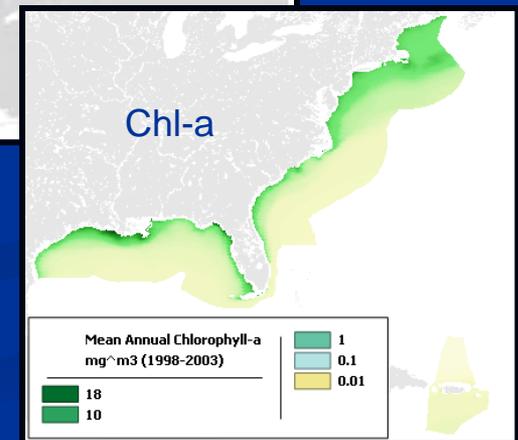
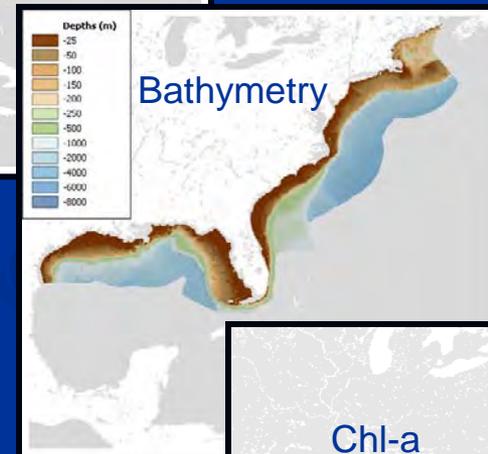
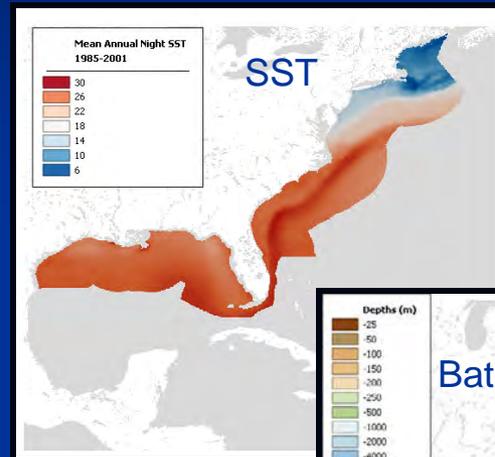
Manifold wins 2008 Geospatial Leadership Award!

Part 3. Data Put to Use: Open Ocean Aquaculture Potential



Harbor locations and attributes

EEZ limits



NOAA Office of Coast Survey

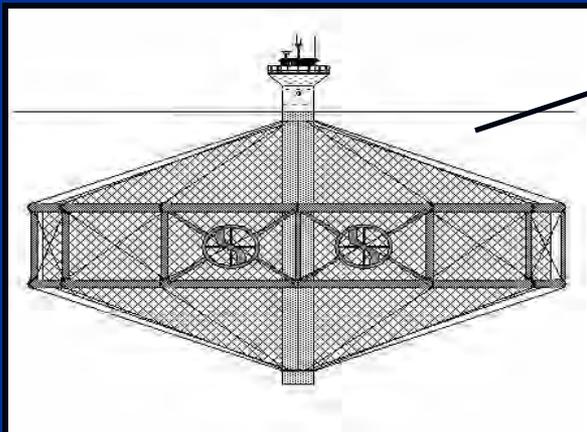
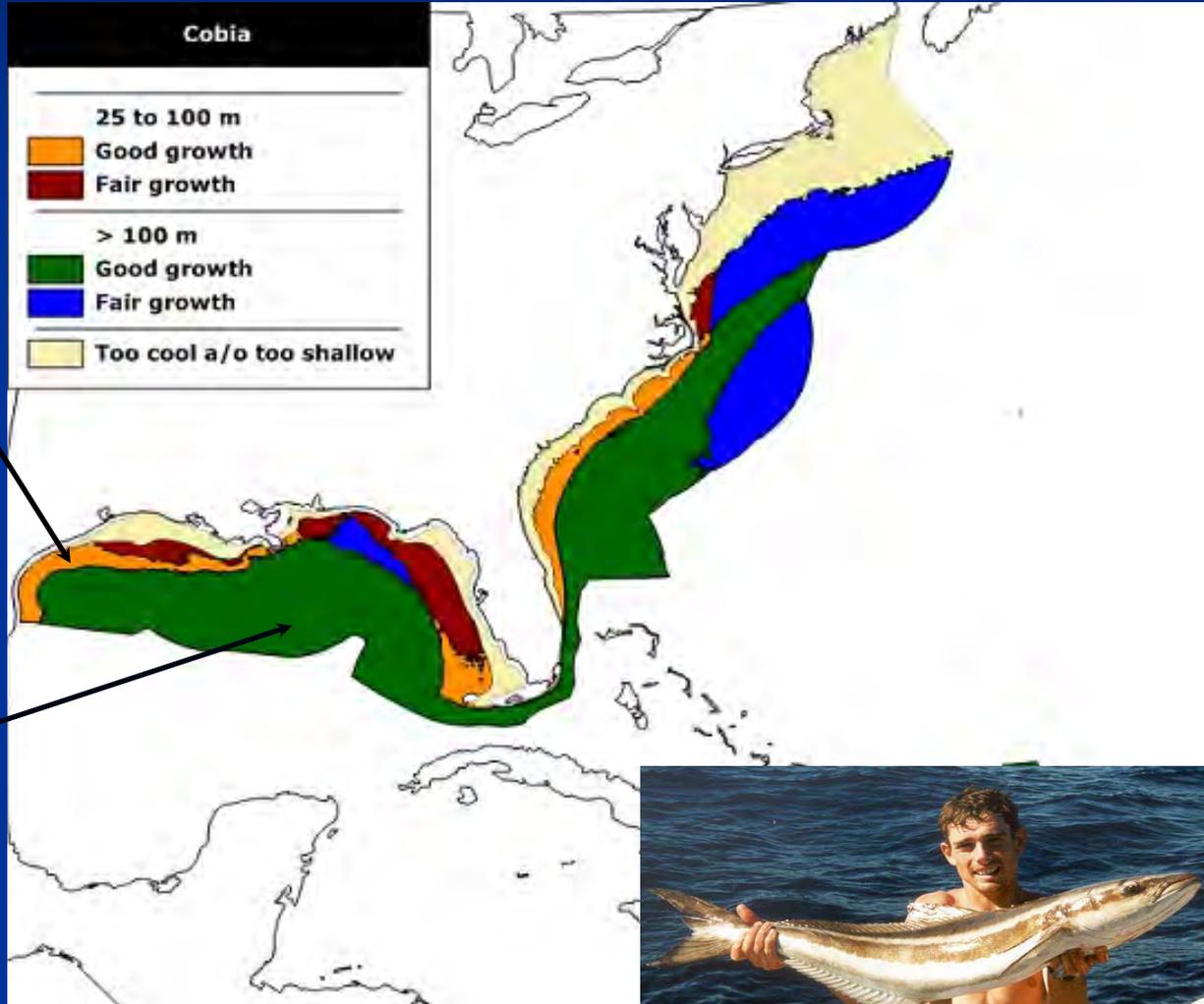
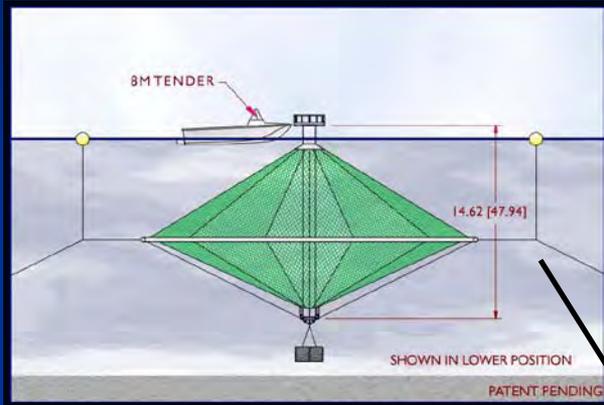
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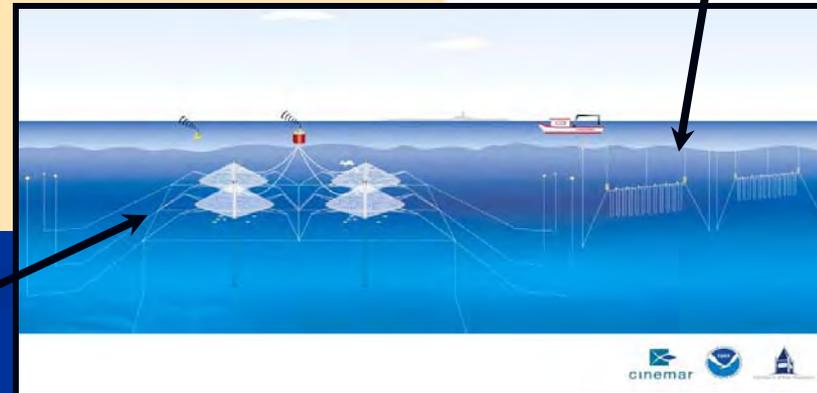
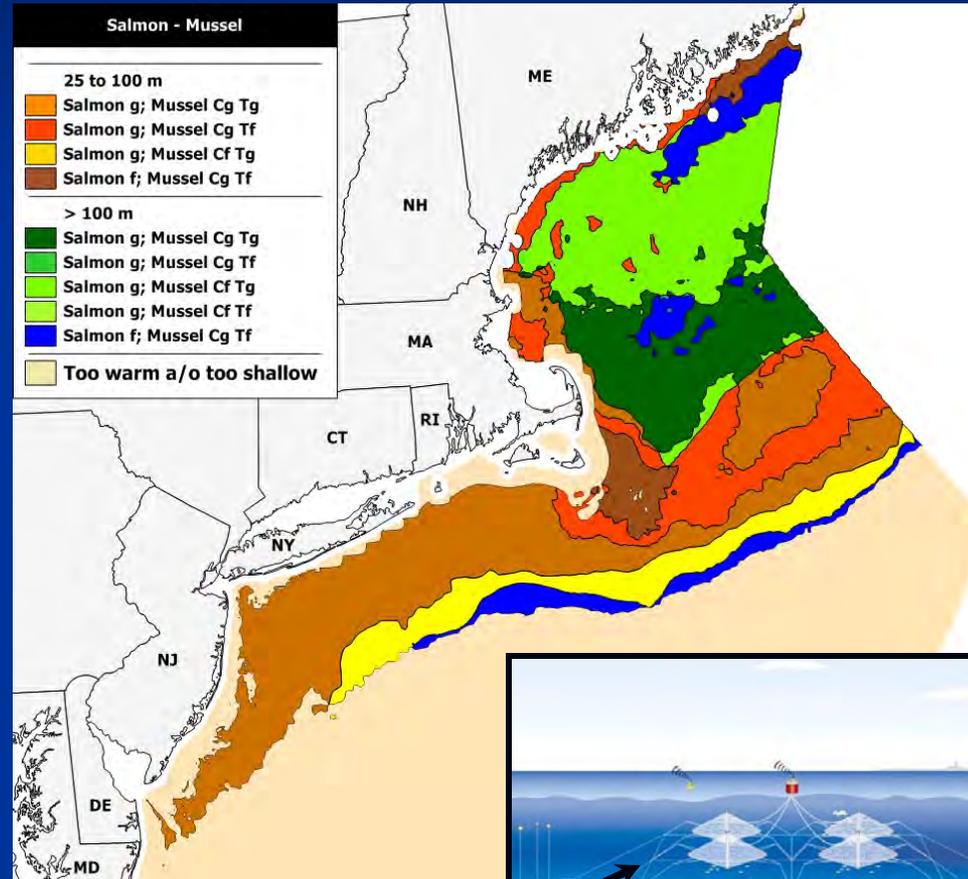
GIS & Other Products Download EEZ limits

Reconnaissance of Present and Future Development Potential of Cobia Culture in EEZs



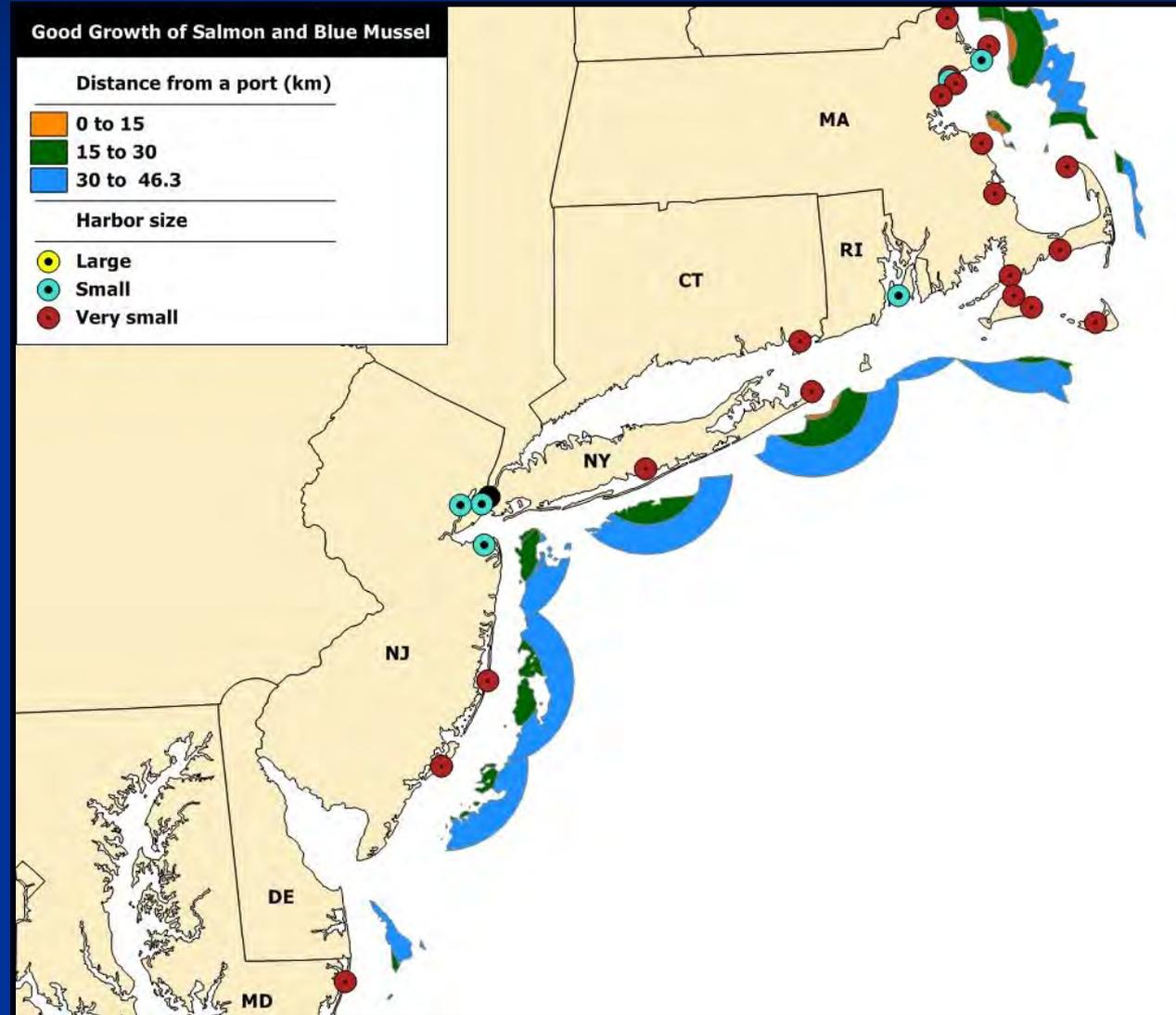
Example of Potential in EEZs that is Environmentally Attuned

- Integrated multi-trophic aquaculture:
 - Atlantic salmon
 - Blue mussel



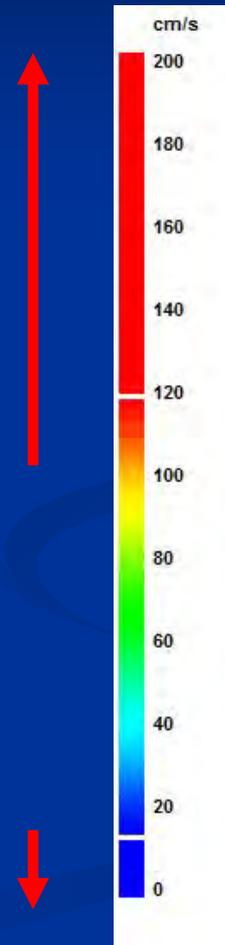
Linking Offshore Aquaculture Potential to Onshore Locations

- Good growth of salmon and mussel offshore
- Commuting distance between harbor and offshore site that is economic
- Harbor size as proxy for goods and services onshore



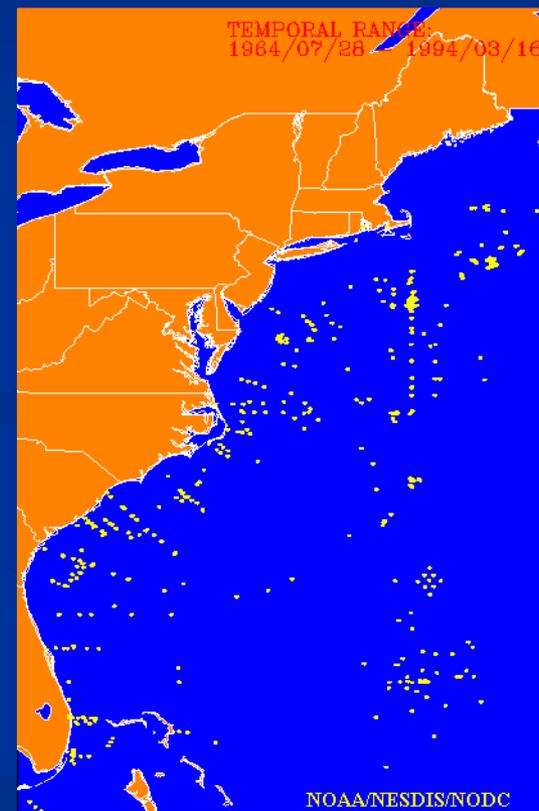
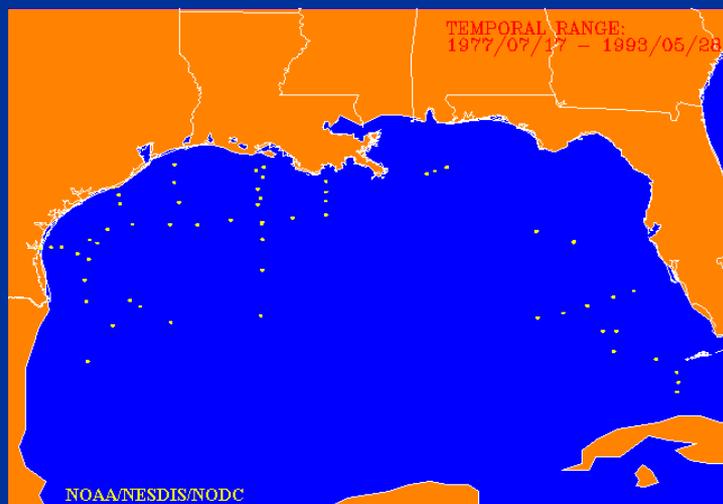
Part 4. Basic Data Gap – Current Speed

- Current speed affects:
 - Culture structures
 - Too fast
 - Cages deform
 - Engineering costs rise
 - Wear and tear increase
 - Cultured organisms
 - Too fast (fishes)
 - Food energy diverted to swimming instead of growth
 - Too slow
 - Wastes and uneaten feed not dispersed (fishes)
 - Low food particle concentration (filter feeders)
 - Low nutrient concentration (plants)

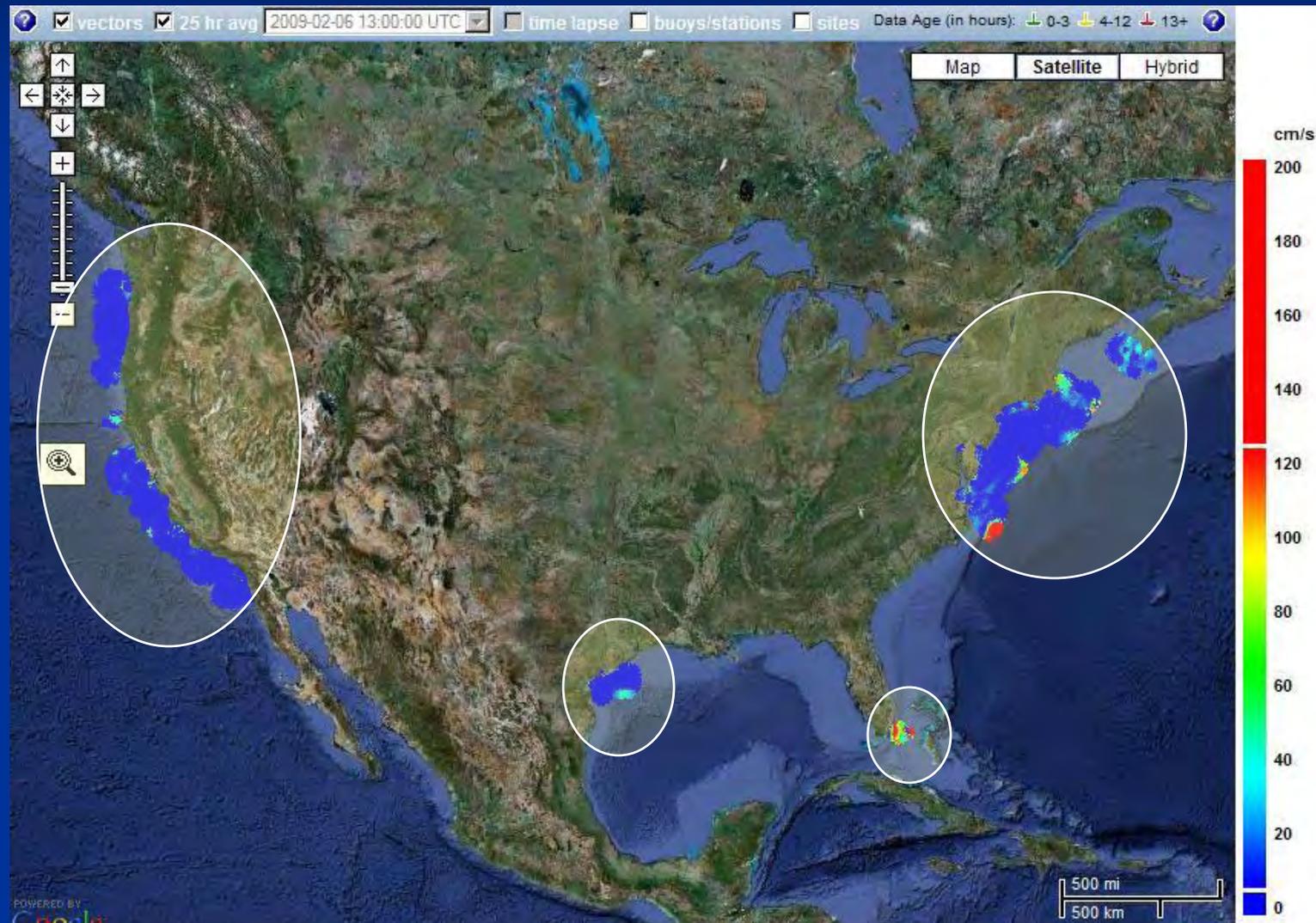


Current Speed – Incomplete Coverage and Resolution Too Low

Time Series Data Base
of coverage at point
locations

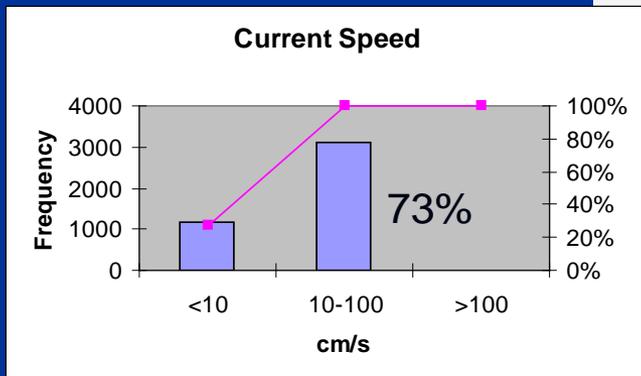
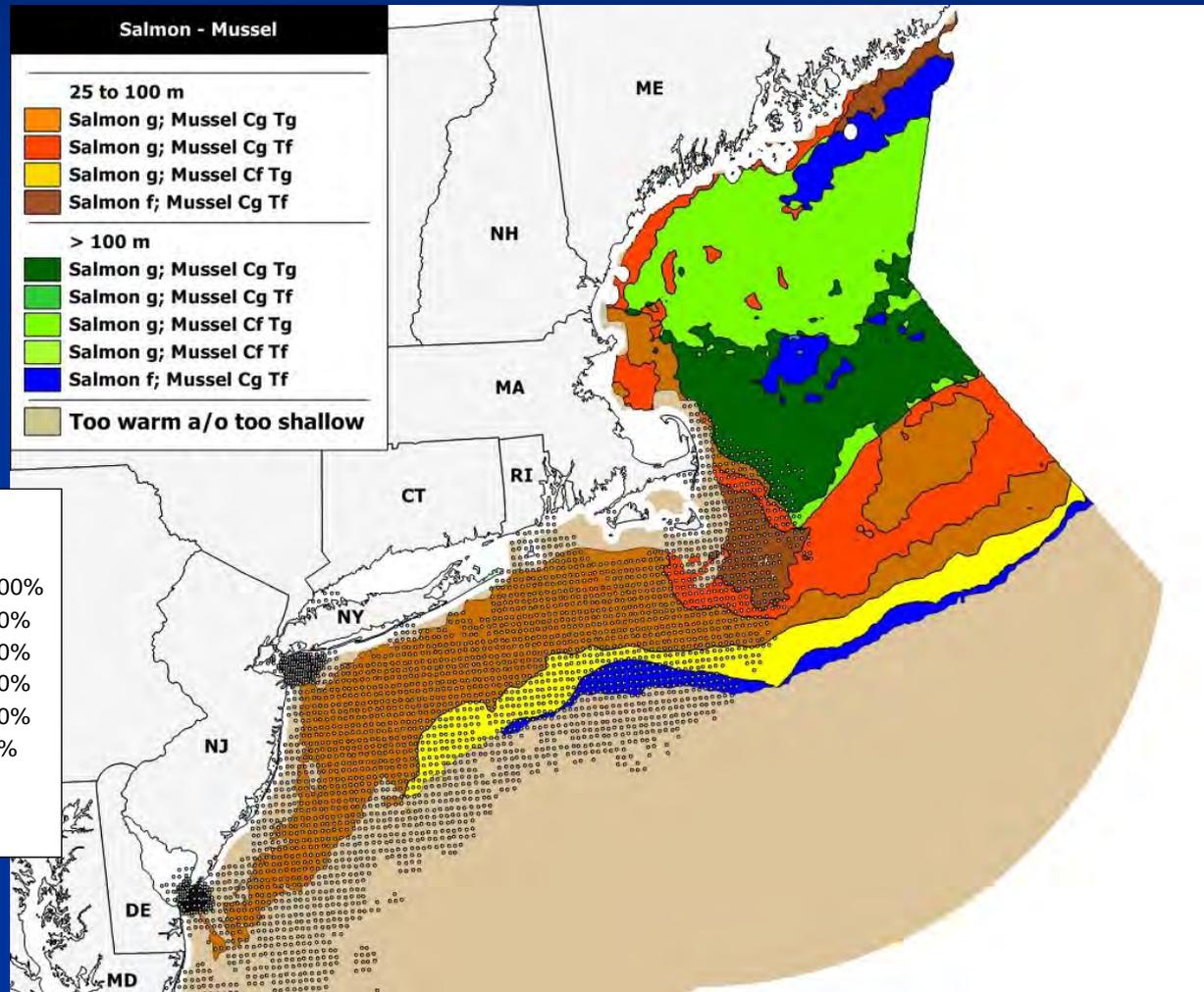


HF Radar Current Speed – Incomplete Spatial Coverage & No 'Climatologies'

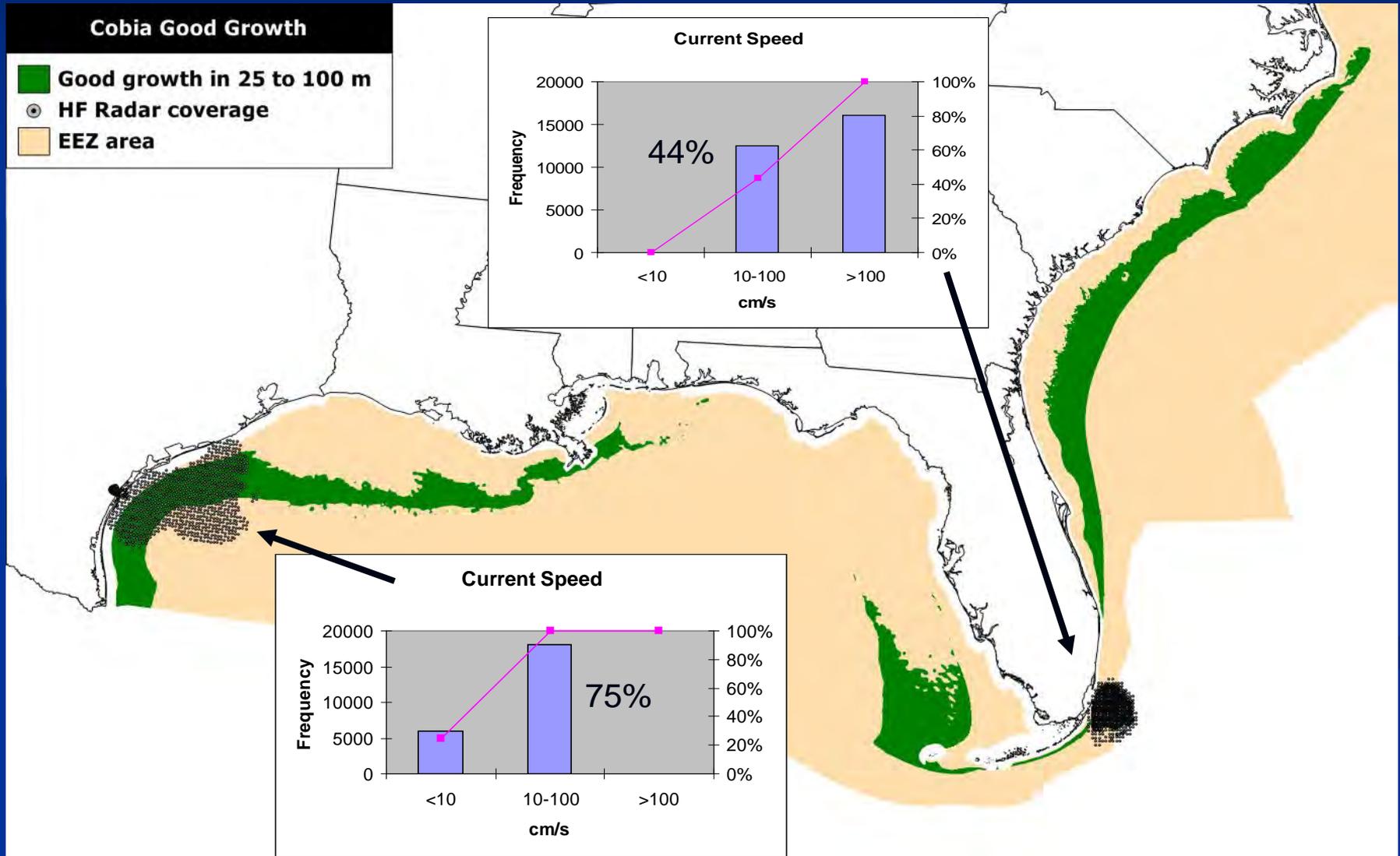


HF Radar Current Speed Coverage for Salmon-Mussel Potential

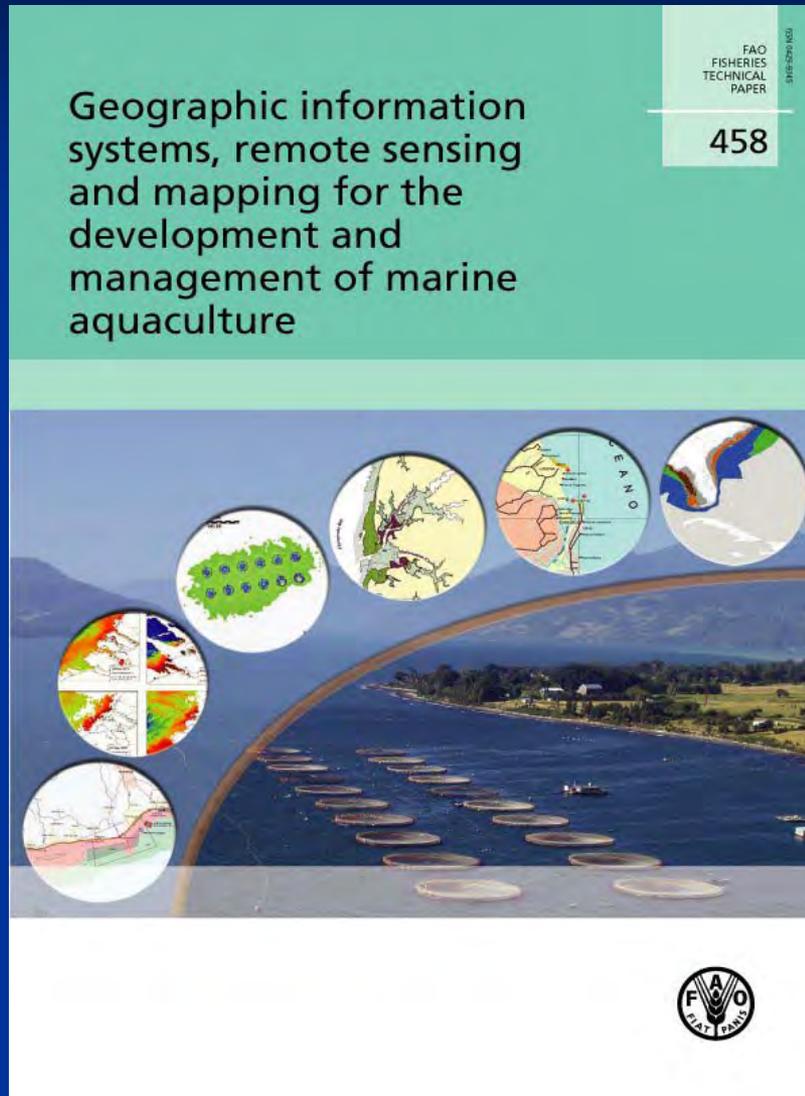
- 1, 2, and 6 km resolution



HF Radar Current Speed Coverage for Cobia Potential



Part 5. Data Sources



NOAA – Many sites and data sets!

Chapter 4, Table 4.3
pp. 84-85

<http://www.fao.org/fishery/gisfish/id/2779>

Conclusions

- OOA development and management are highly dependent on diverse data both onshore and offshore
- Data needs are dictated by:
 - Level and timing of development
 - (Potential=>Zoning=>Siting=>Operations)
- With the exception of current speed, data are adequate for estimating OOA potential offshore
- High resolution, near coast data are needed to support onshore and offshore aquaculture zoning and site selection and for aquaculture operations
- Many of the data sets required for OOA are from NOAA

Acknowledgements

- Photos and diagrams
 - NOAA
 - Atlantic Marine Aquaculture Center, UNH
 - Cliff Goudey, MIT
 - Ryan (2004) "Farming the Deep Blue"
 - Fish cage manufacturers

Thank you!



Hats off to NOAA for their data initiatives and tools!