CORE 2016

A Forward Thinking Approach to Marine Renewable Energy Development Through Marine Spatial Planning

Crow White, Cal Poly - SLO

Recreation

LNG

Offshore oil

Aquaculture

Shipping

Fisheries

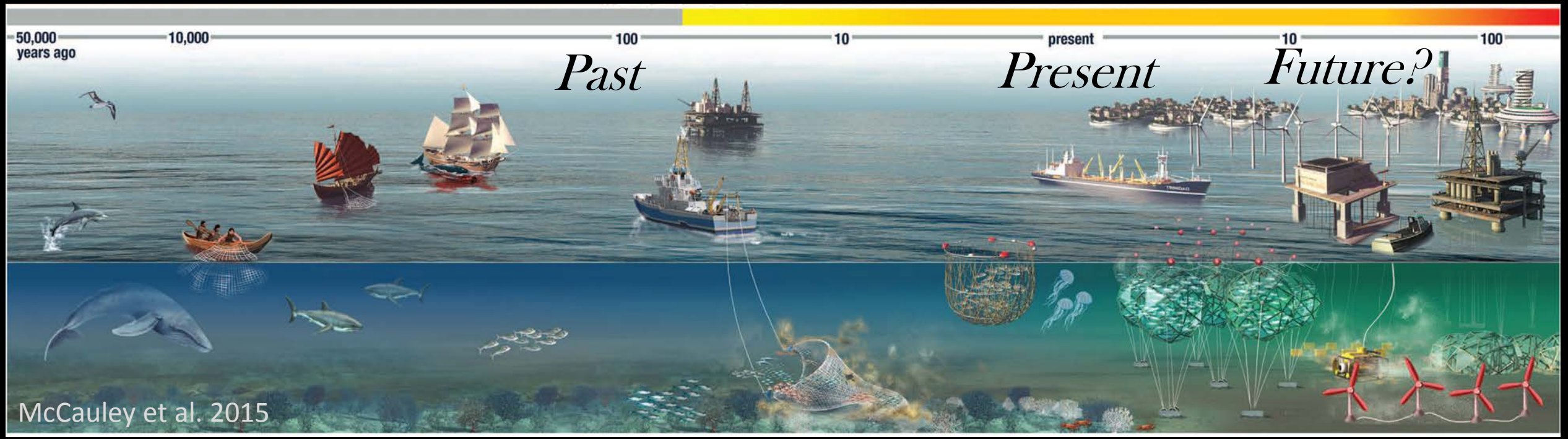
Protected areas

Healthy ecosystems

Protected species

Clean water

Coastal Views



McCauley et al. 2015

Forward thinking approach to marine renewable energy


Siemens

Manage conflicts and benefits

- What could be impacted?
- What could benefit?
- Where? Why? How strongly?
- Can these effects be mitigated/enhanced?

Create synergies

- What can be co-located?
  - Energy-Energy
  - Energy-Other

Promote ecosystem-based solutions

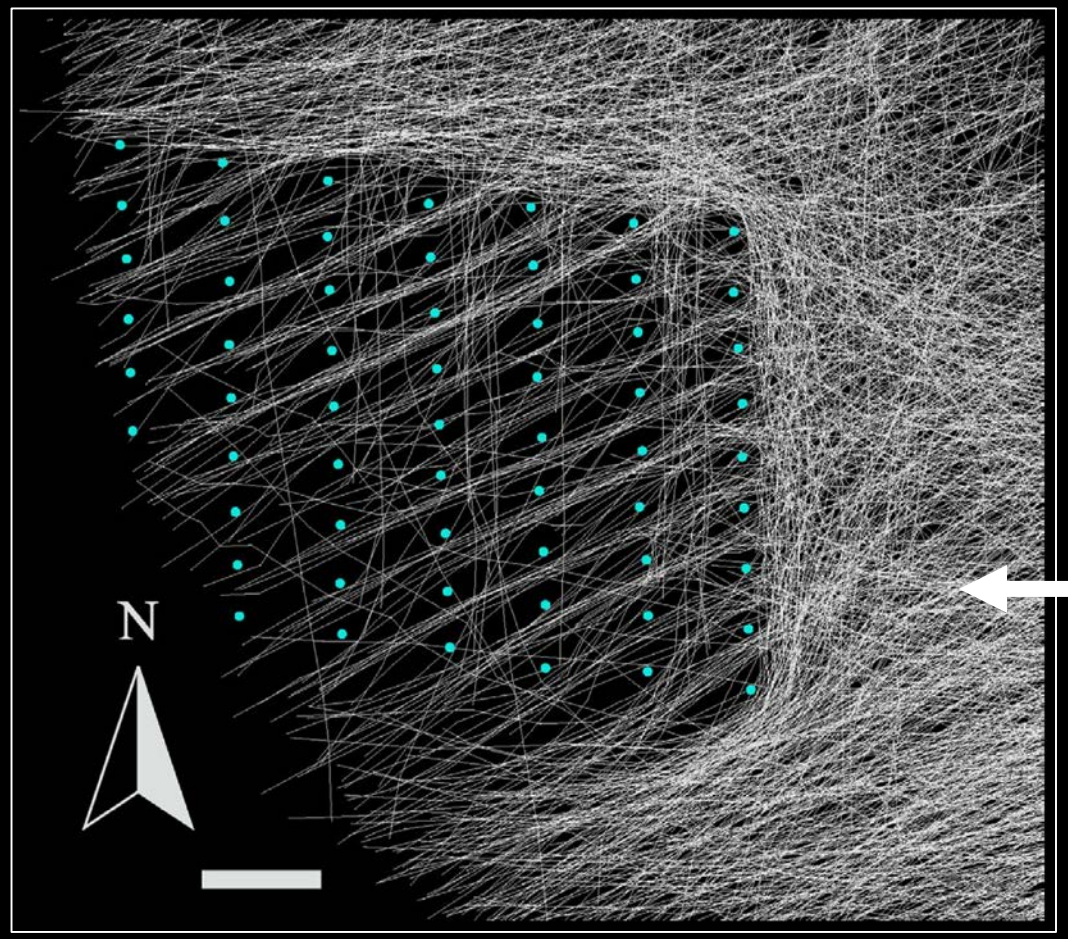
- Productive, efficient and sustainable

Manage conflicts and benefits

Environmental effects

Seabirds

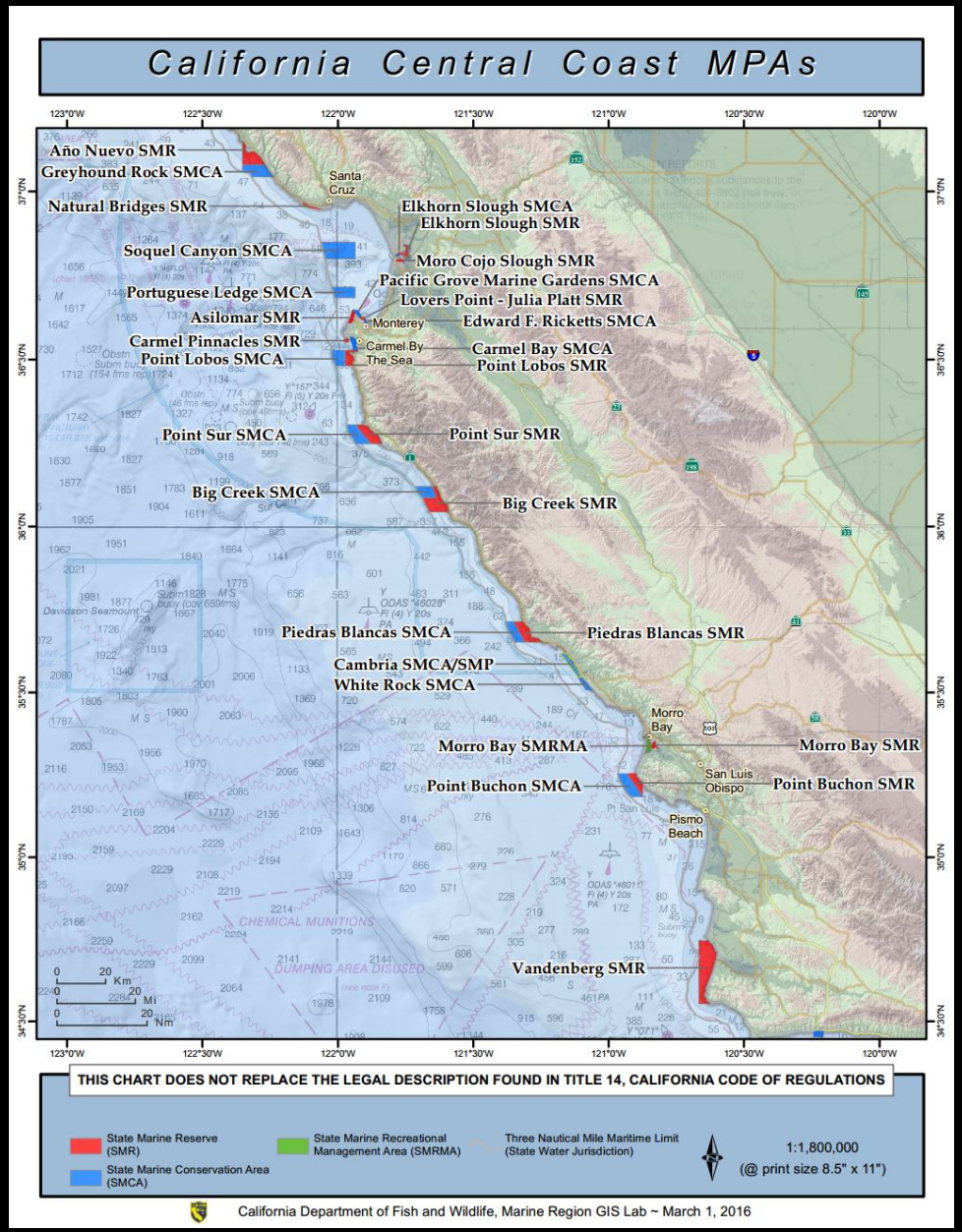
- Collisions and Displacement
- Field location and design



Bird flight paths around and through offshore wind farm

Desholm and Kahlert 2005

Manage conflicts and benefits



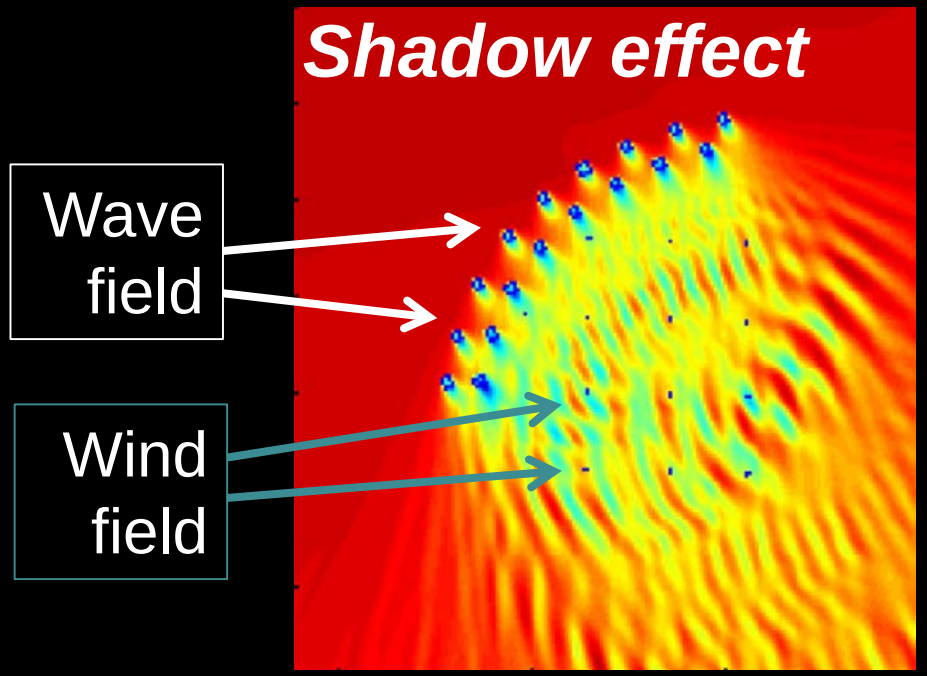
Environmental effects

Seabirds
- Collisions and Displacement
  - Field location and design

Marine fish and invertebrates
- Can create habitat & boost biomass
  - Pylon/mooring design and depth
- Can create marine refuge
  - Location and configuration
    - Conservation & Fisheries goals

Claisse et al. 2014, Freeman et al. 2016, Hammar et al. 2016, Love et al. 1999

Create synergies



<u>Energy-Energy</u>

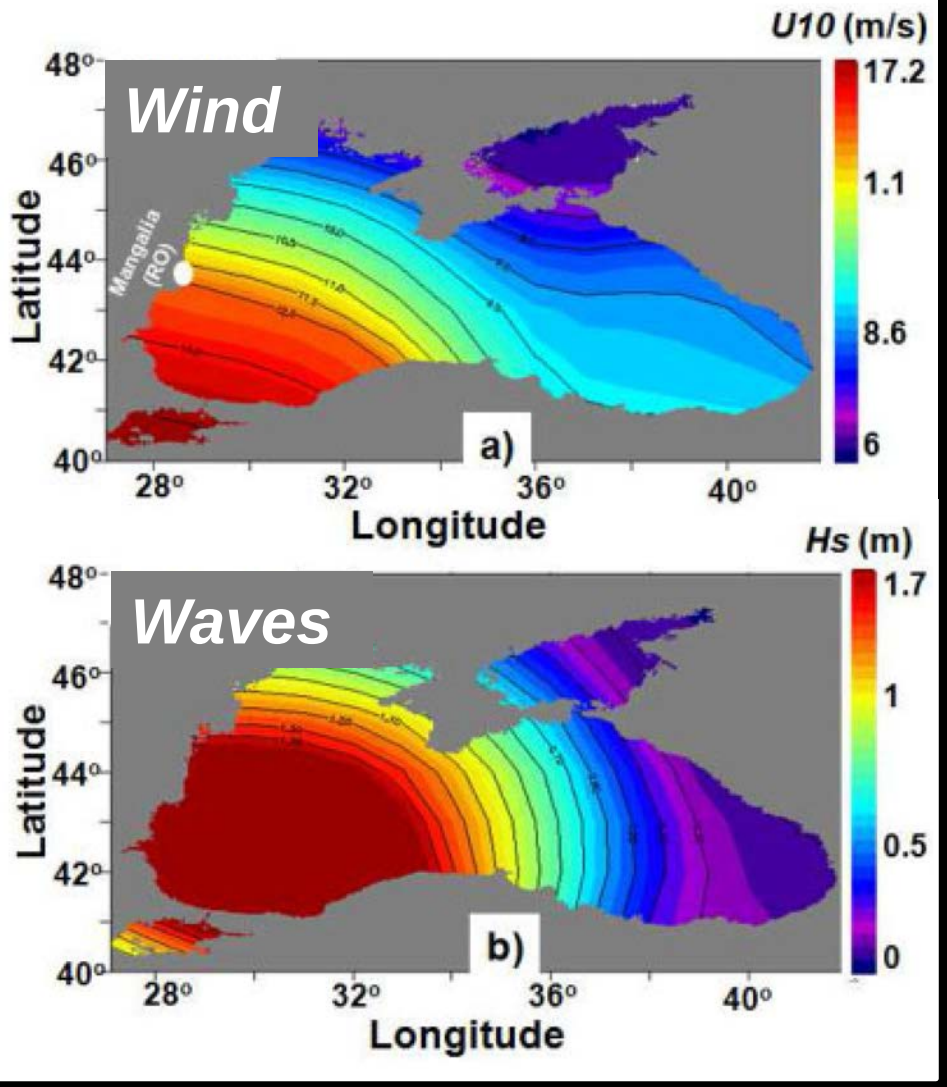
Co-locate wave and wind energy systems

- Enhance production and consistency
- Improve operation and maintenance

Onea et al. 2016
Perez-Collazo et al. 2015
Astariz et al. 2015
Astariz et al. 2016

Create synergies

Black Sea, Europe



Energy-Energy

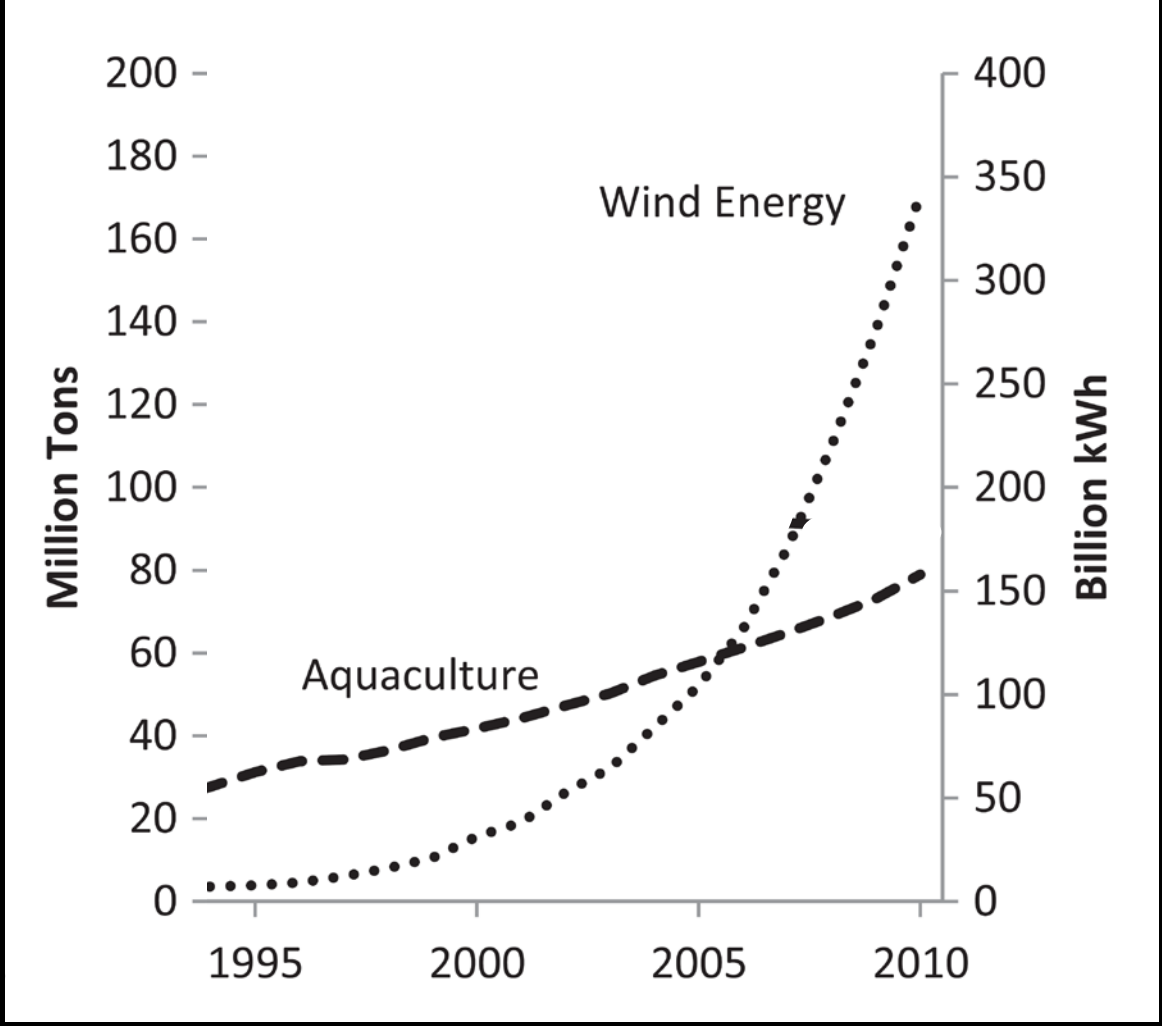
Co-locate wave and wind energy systems

- Enhance production and consistency
- Improve operation and maintenance

- *Objectives*
  - Identify appropriate locations
  - Incentivize for integrative technology

Onea et al. 2016
Perez-Collazo et al. 2015
Astariz et al. 2015
Astariz et al. 2016

Create synergies



Energy-Other

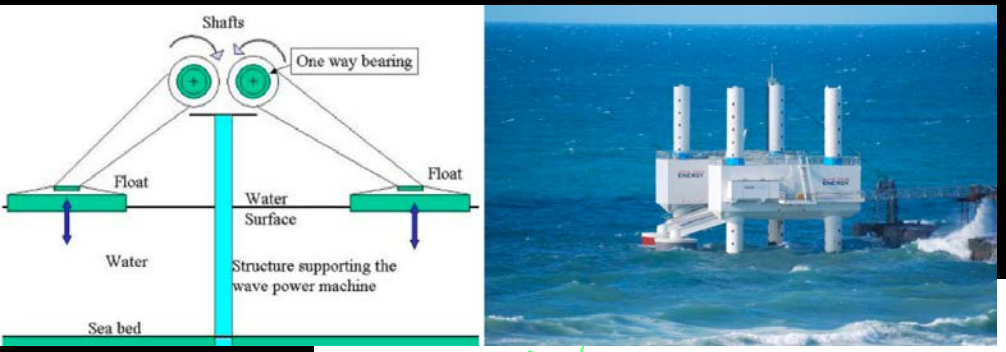
Co-locate energy with aquaculture systems

- Large energy field in high energy waters far from shore. Aquaculture:
  - ➢ Good water quality
  - ➢ Large production potential
  - ➢ Cost-sharing of maintenance
  - ➢ Harsh on aquaculture structure
  - ➢ High development costs
  - ➢ Safety concerns for workers
- *Objectives*
  - Identify appropriate locations

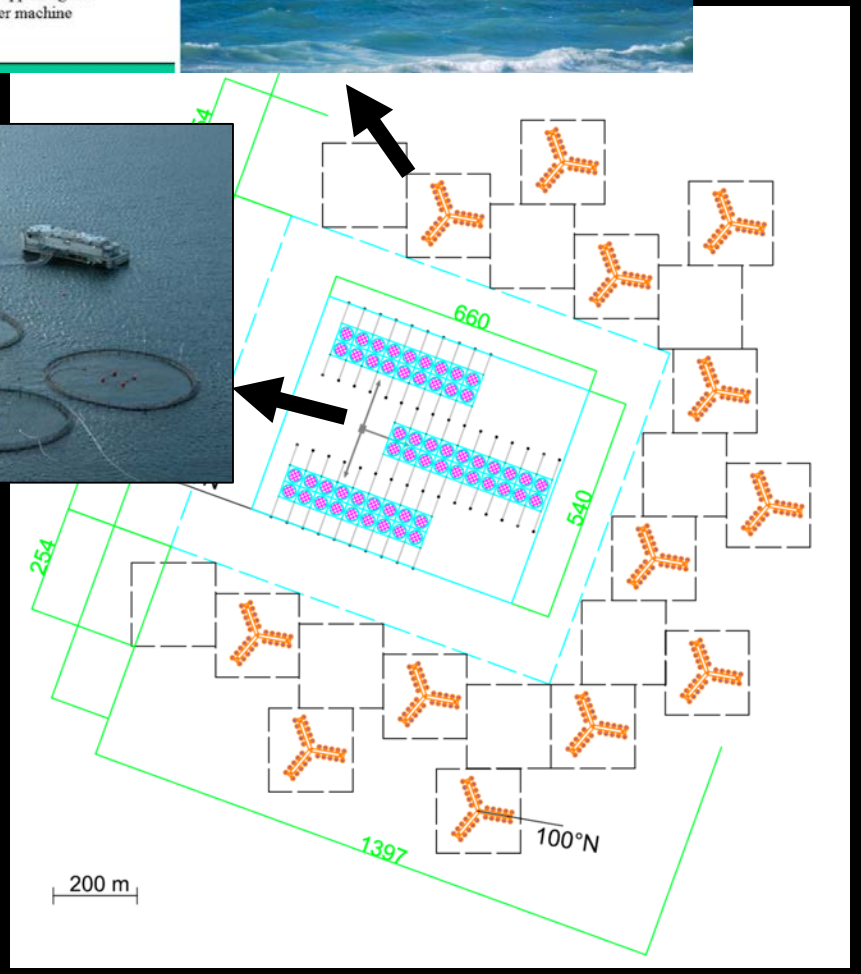
Griffin et al. 2015

Create synergies

Wave machine



Fish farm



Zanuttigh et al. 2015

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  - ➢ High development costs
  - ➢ Safety concerns for workers
- *Objectives*
  - Identify appropriate locations
  - Integrate design and technology
  - Create supportive socio-economic and legal framework

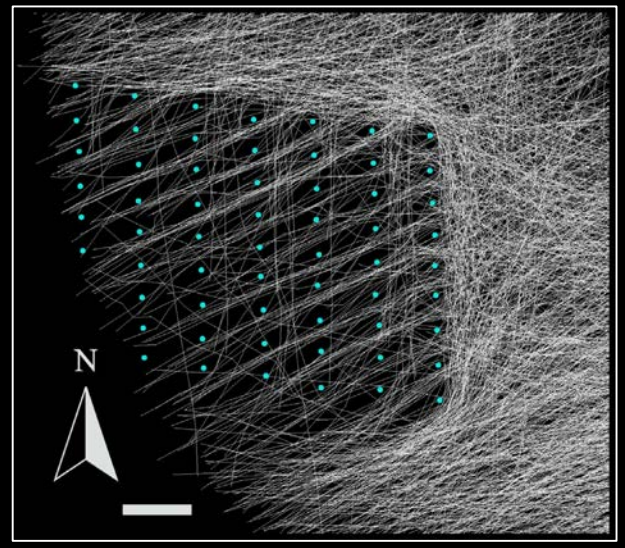
Griffin et al. 2015

Promote ecosystem-based solutions

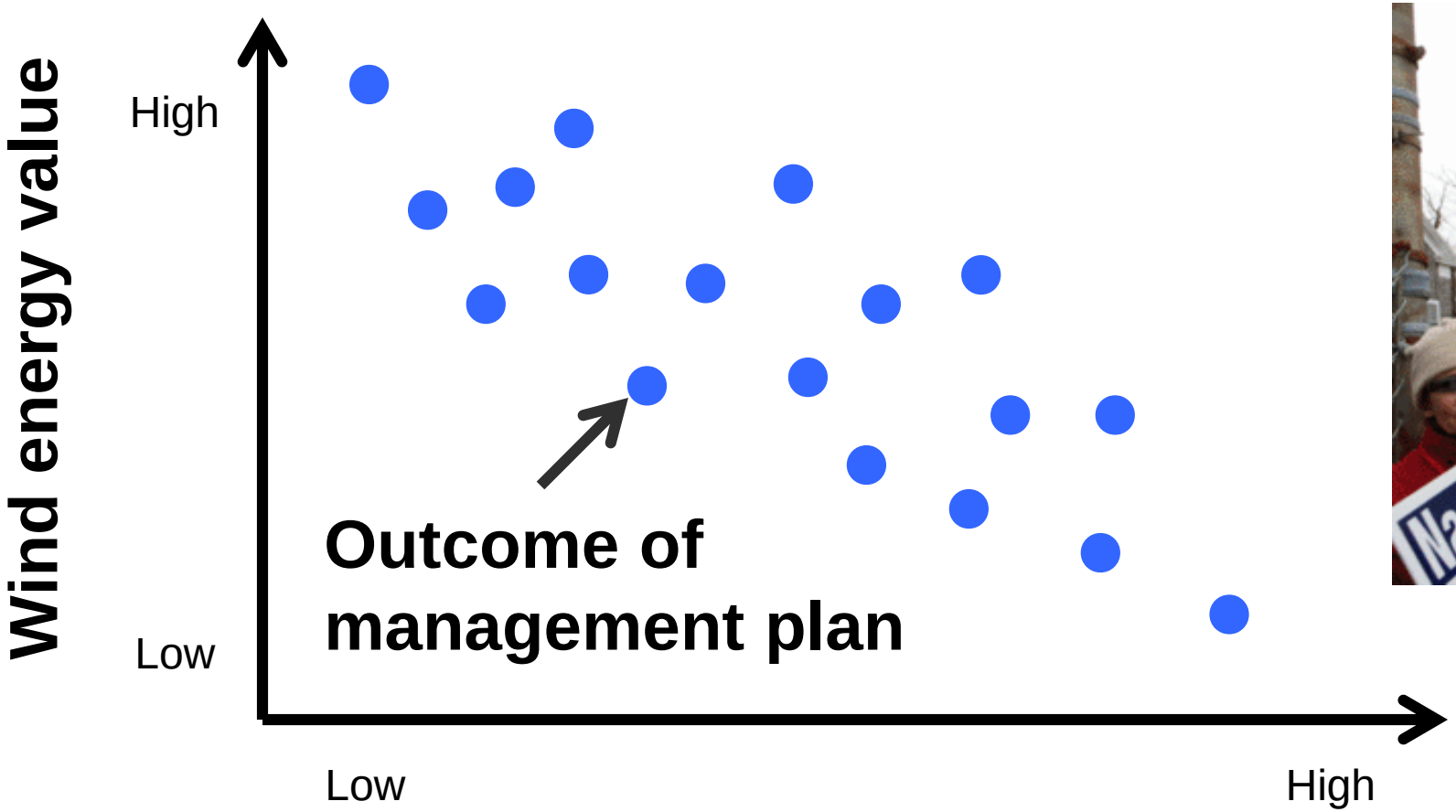
Productive, efficient and sustainable energy systems that best manage conflicts and benefits and utilize synergies.

- Existing and future
  - ➢ Models of current and potential technologies, actions and interactions: Industry-informed, place-based and policy-realistic
- There will be tradeoffs
  - ➢ Tradeoff Analysis of pros and cons of alternative policy decisions

Marine Spatial Planning for guiding marine renewable energy development



Marine Spatial Planning using Tradeoff Analysis



Markowitz 1952
Lester et al. 2012

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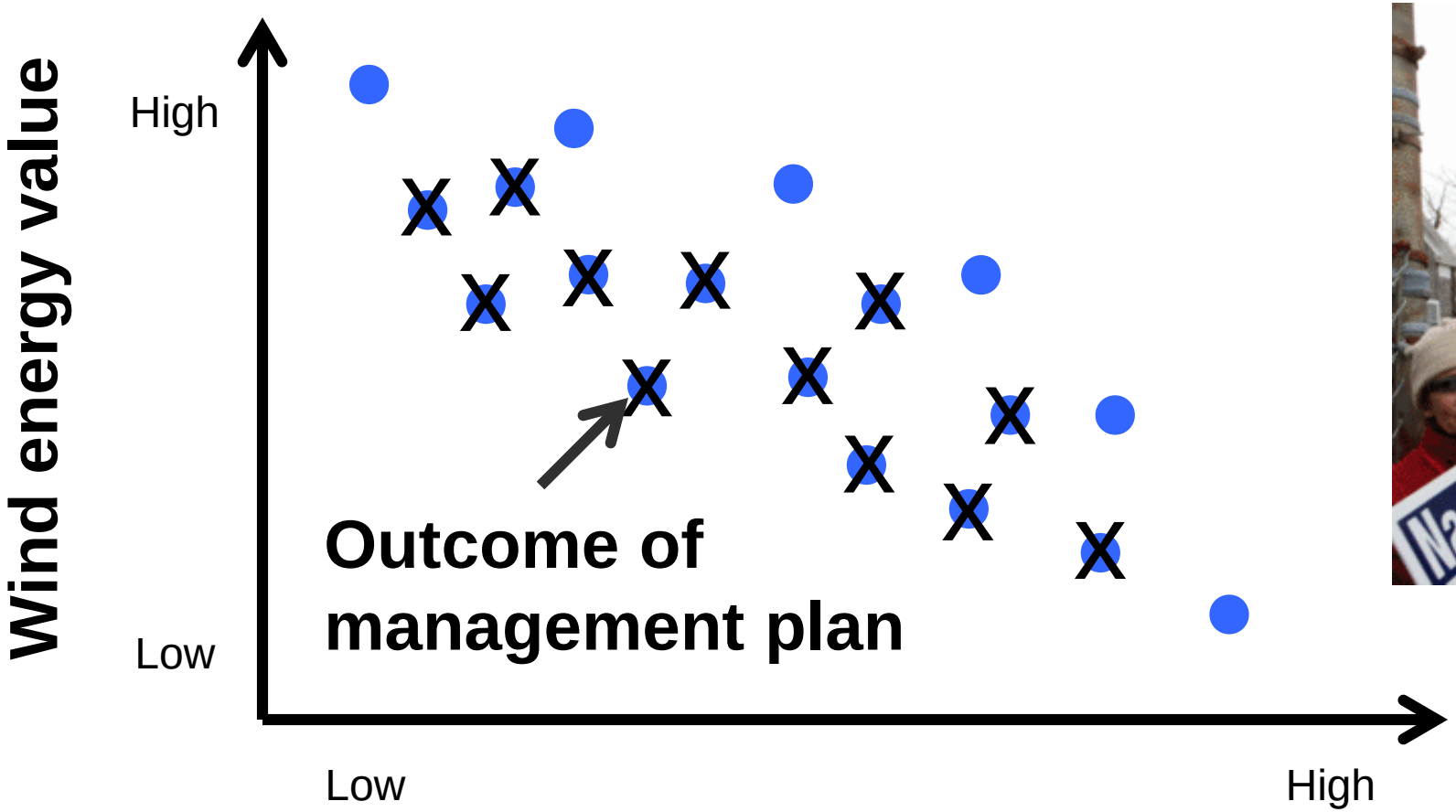

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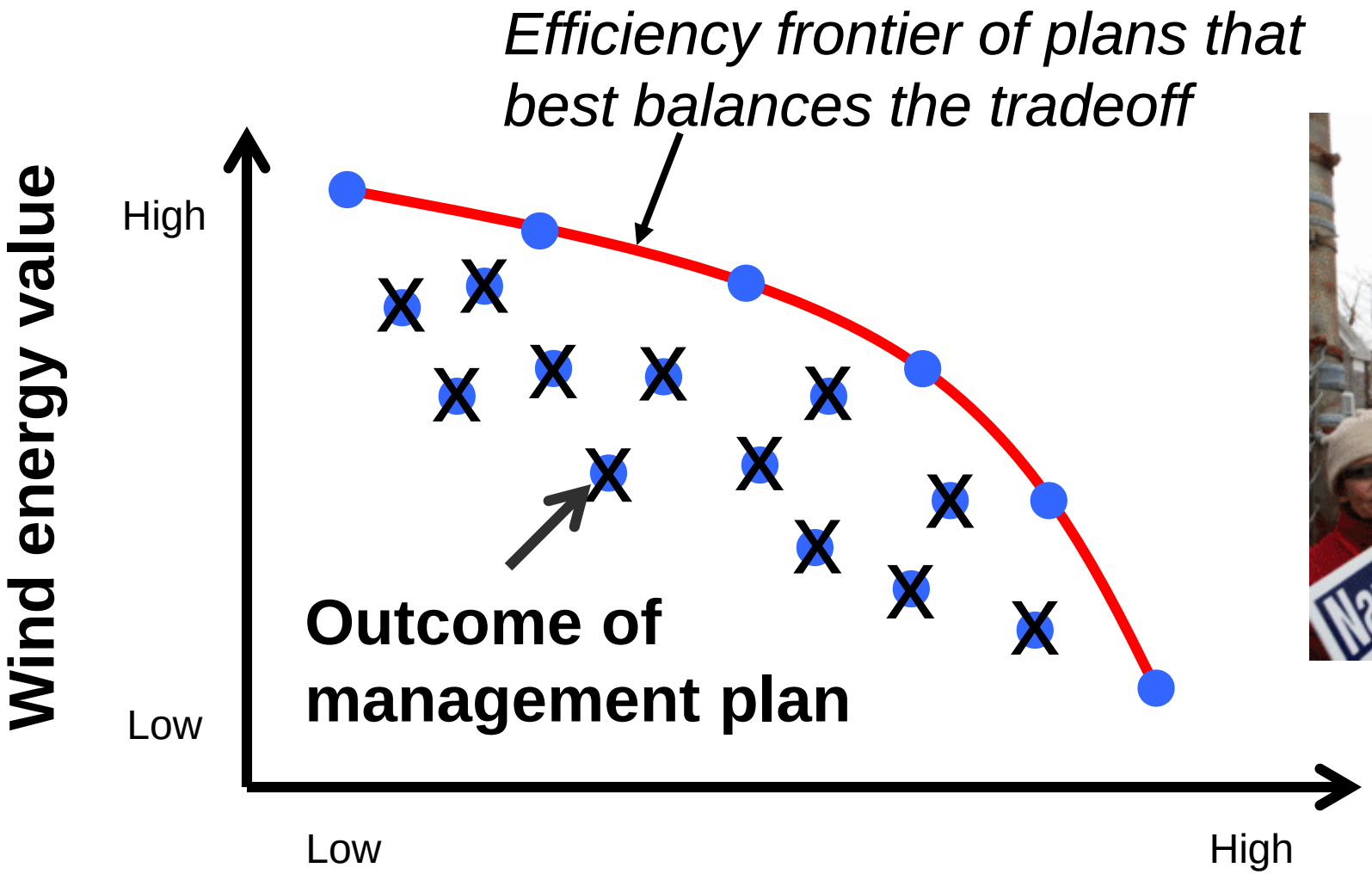

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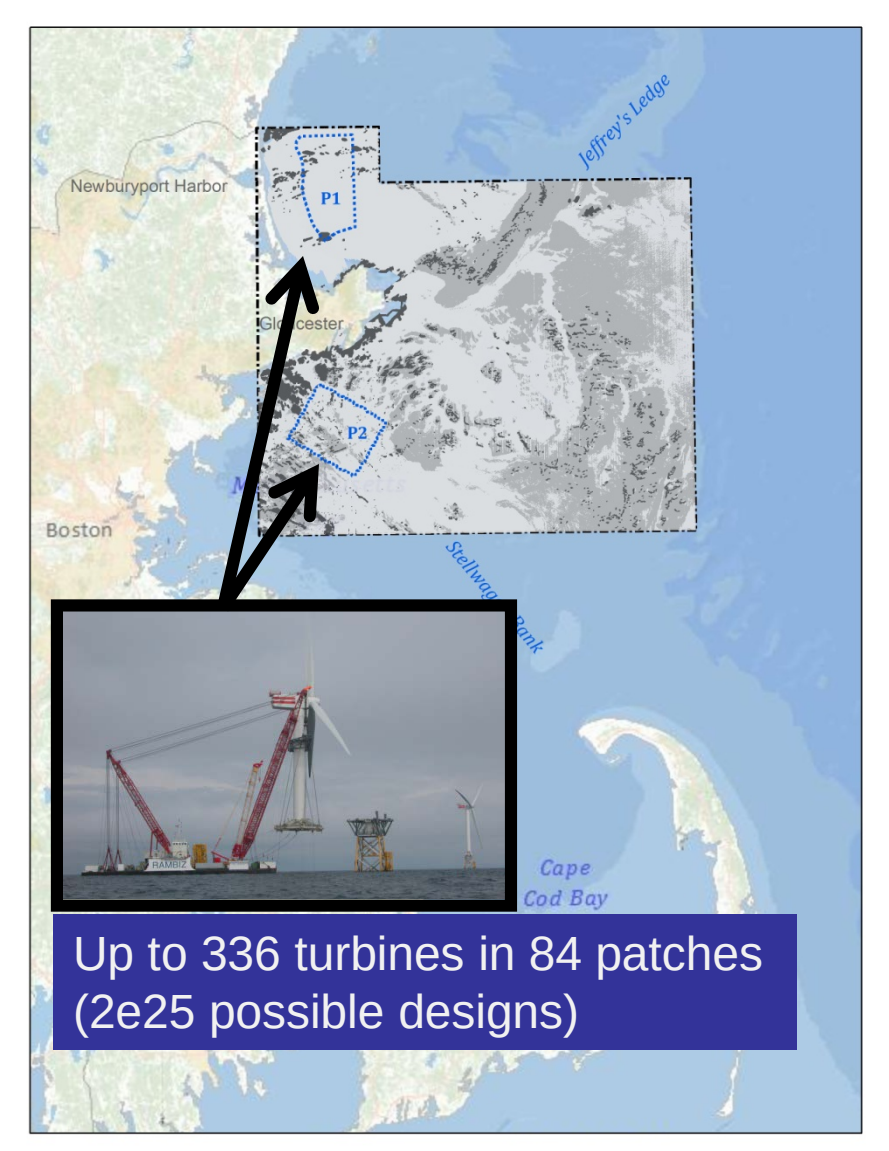
Wind farm development in Massachusetts



White, Halpern and Kappel. 2012. *PNAS*

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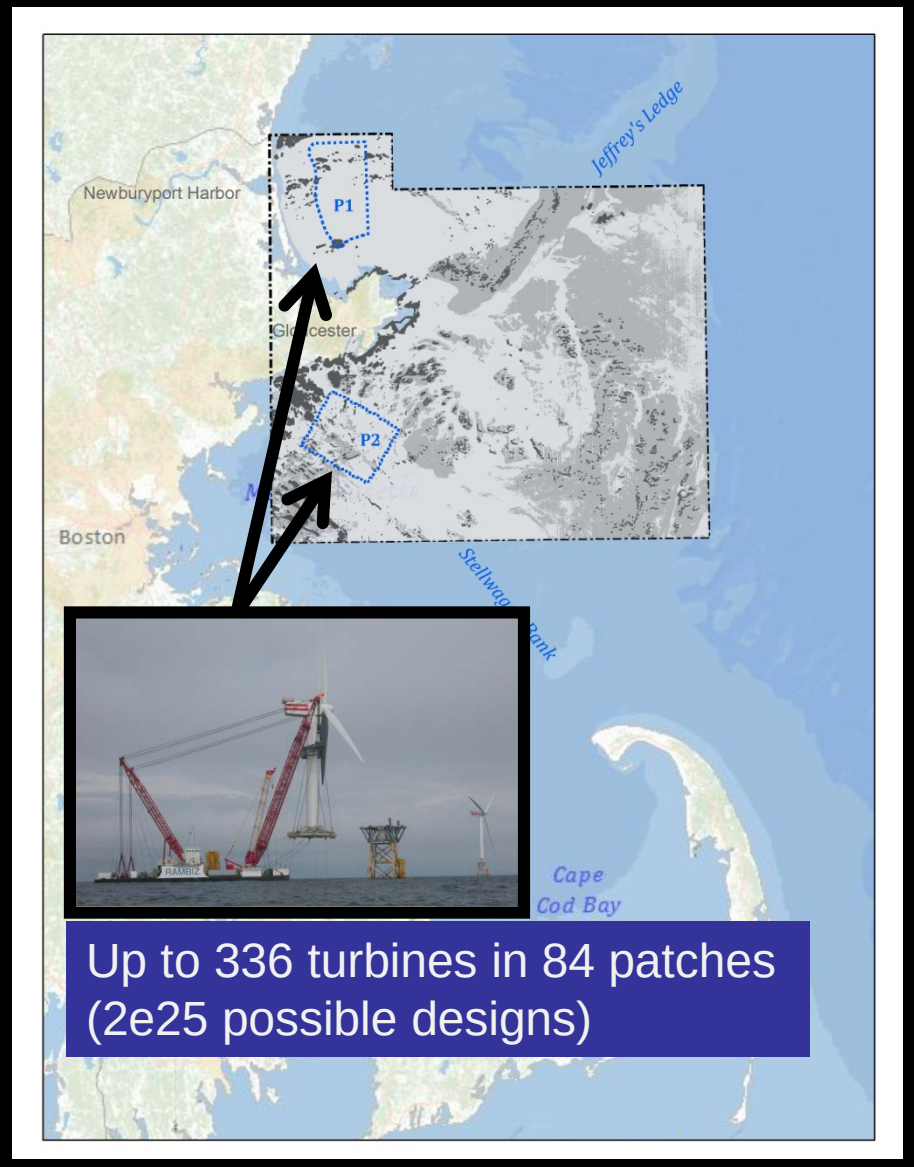

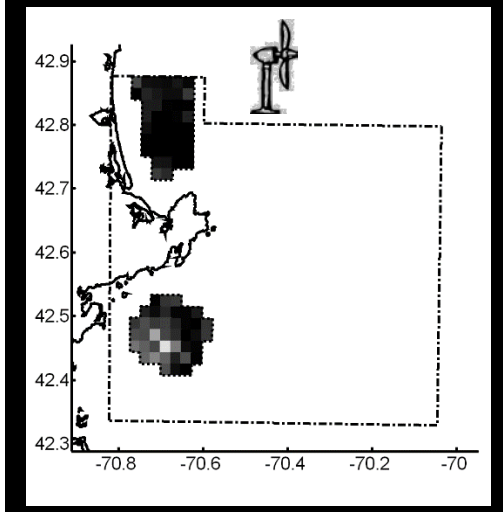

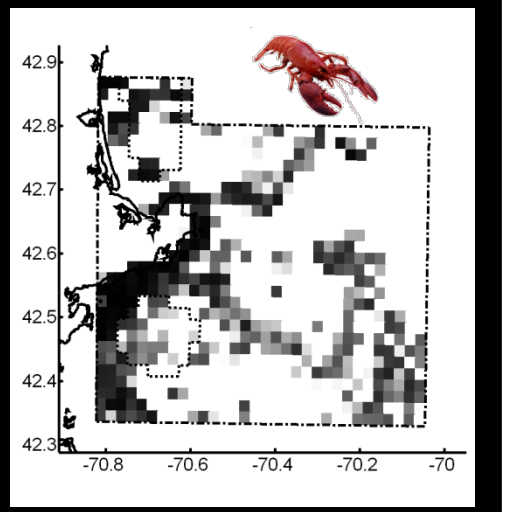

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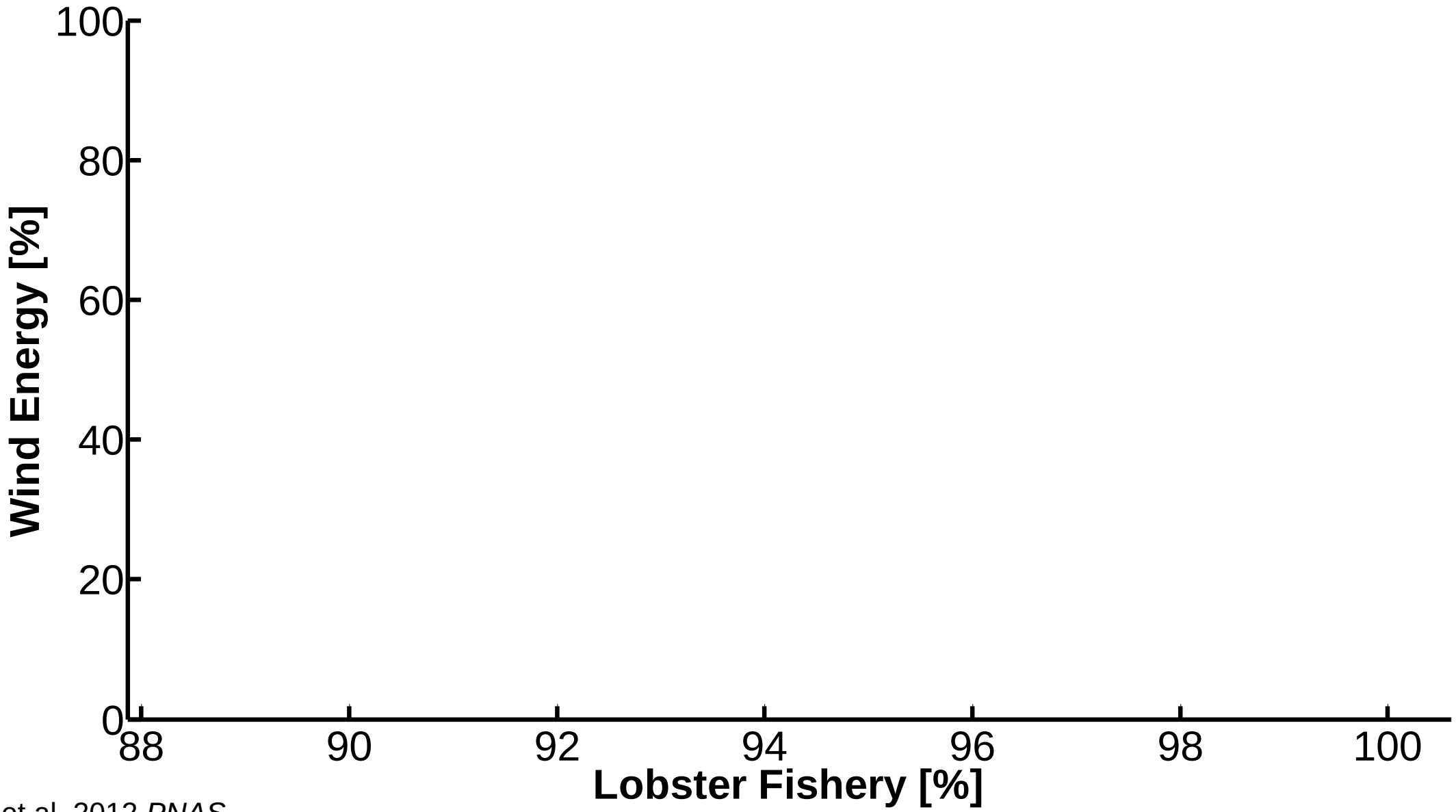

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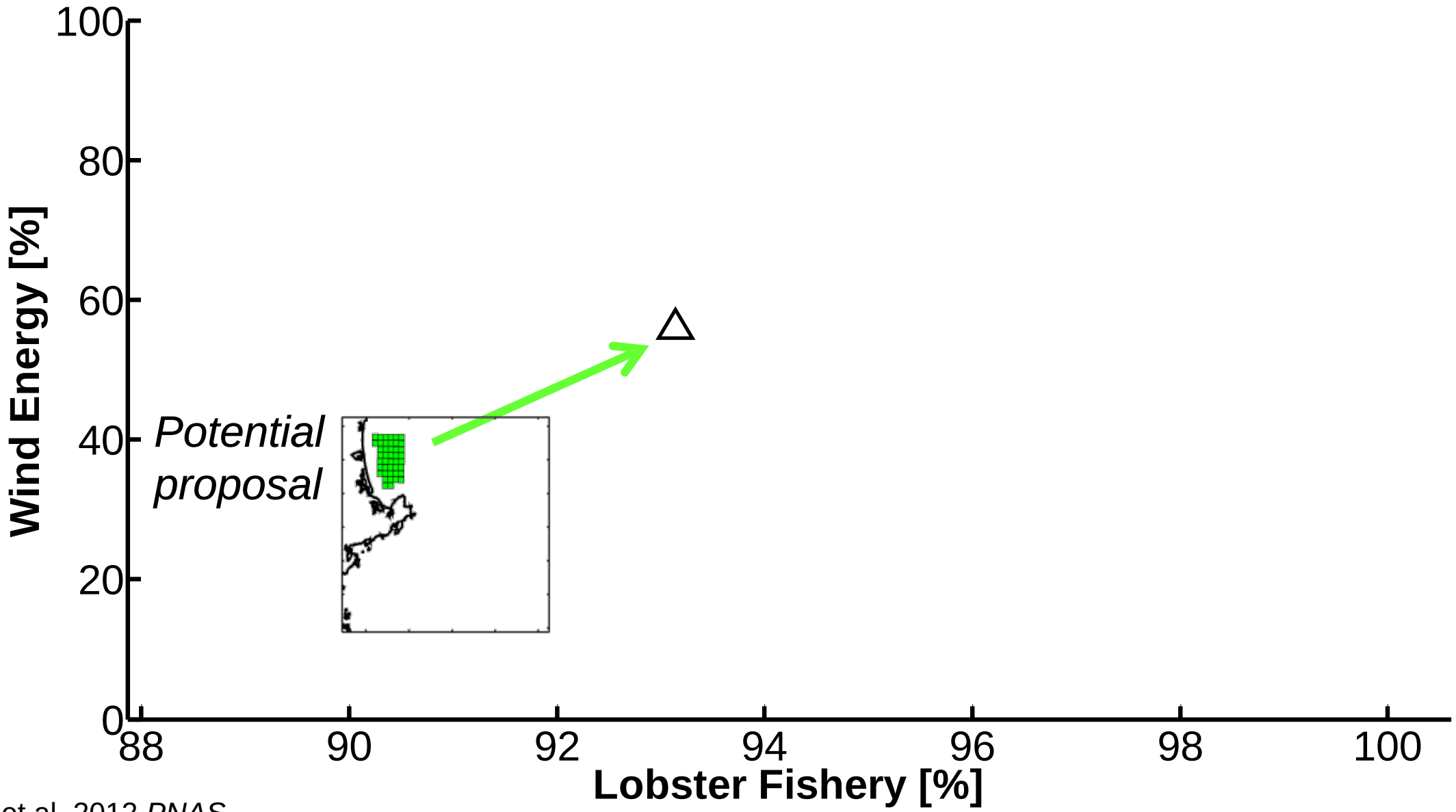

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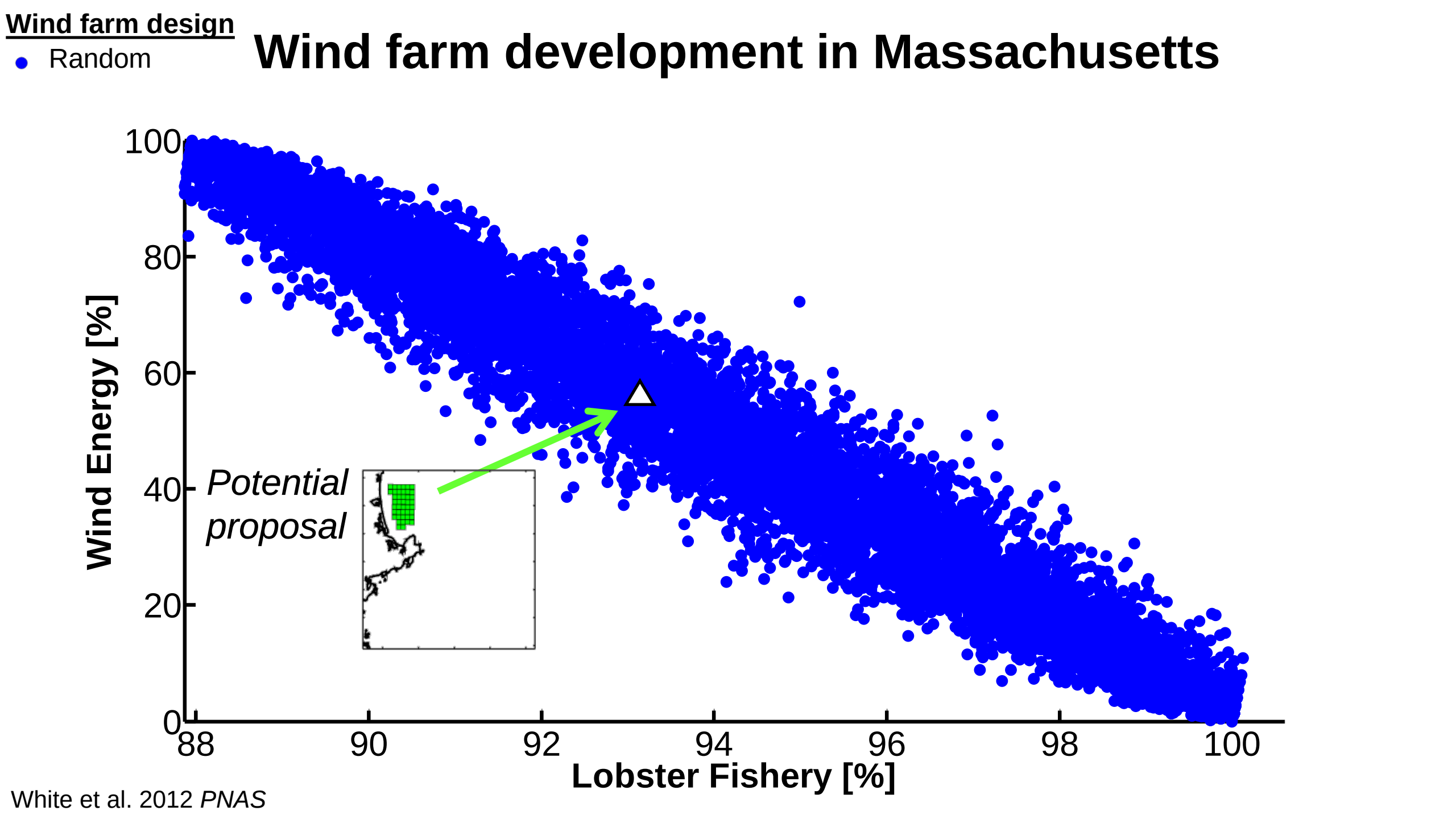

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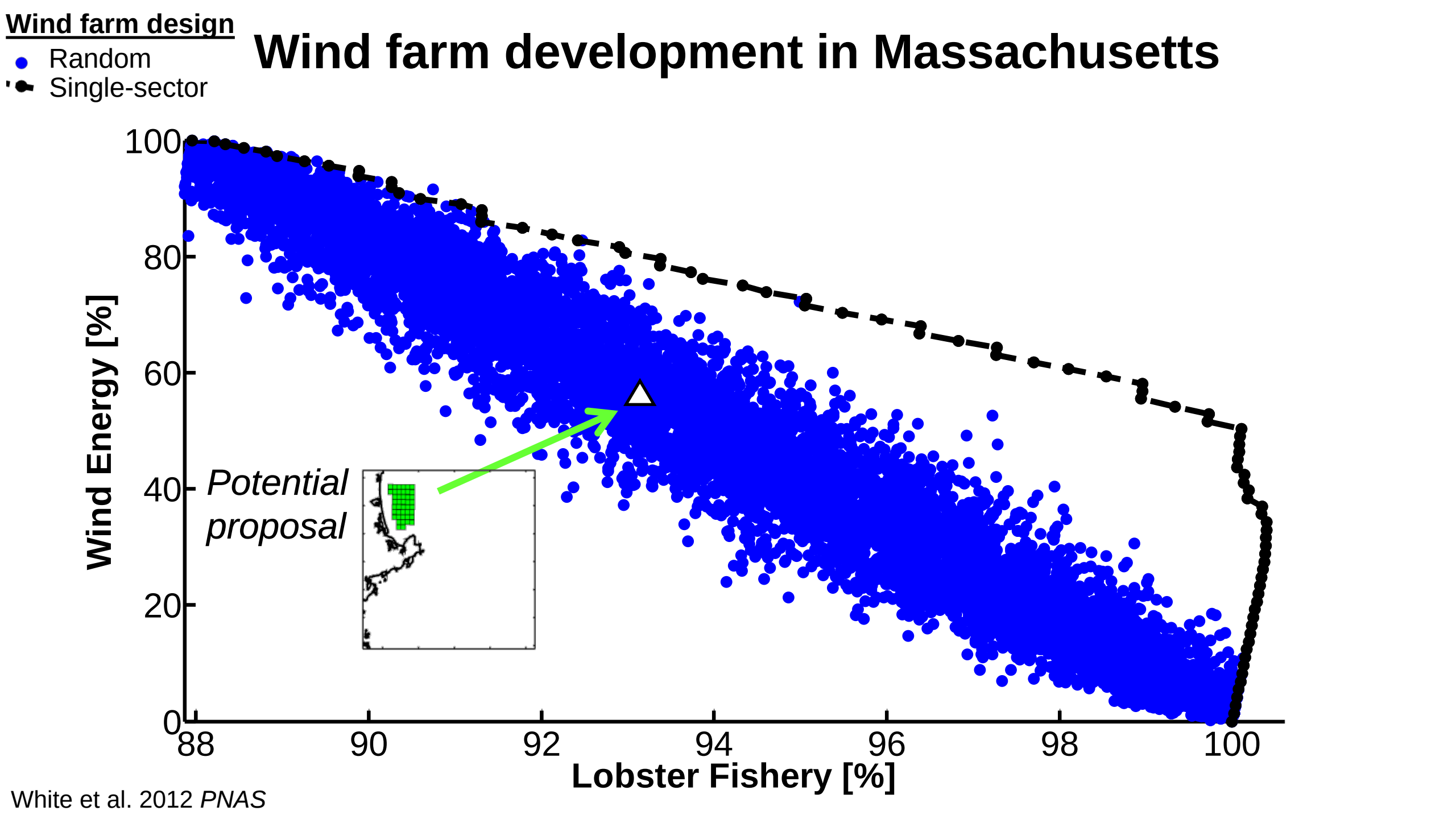

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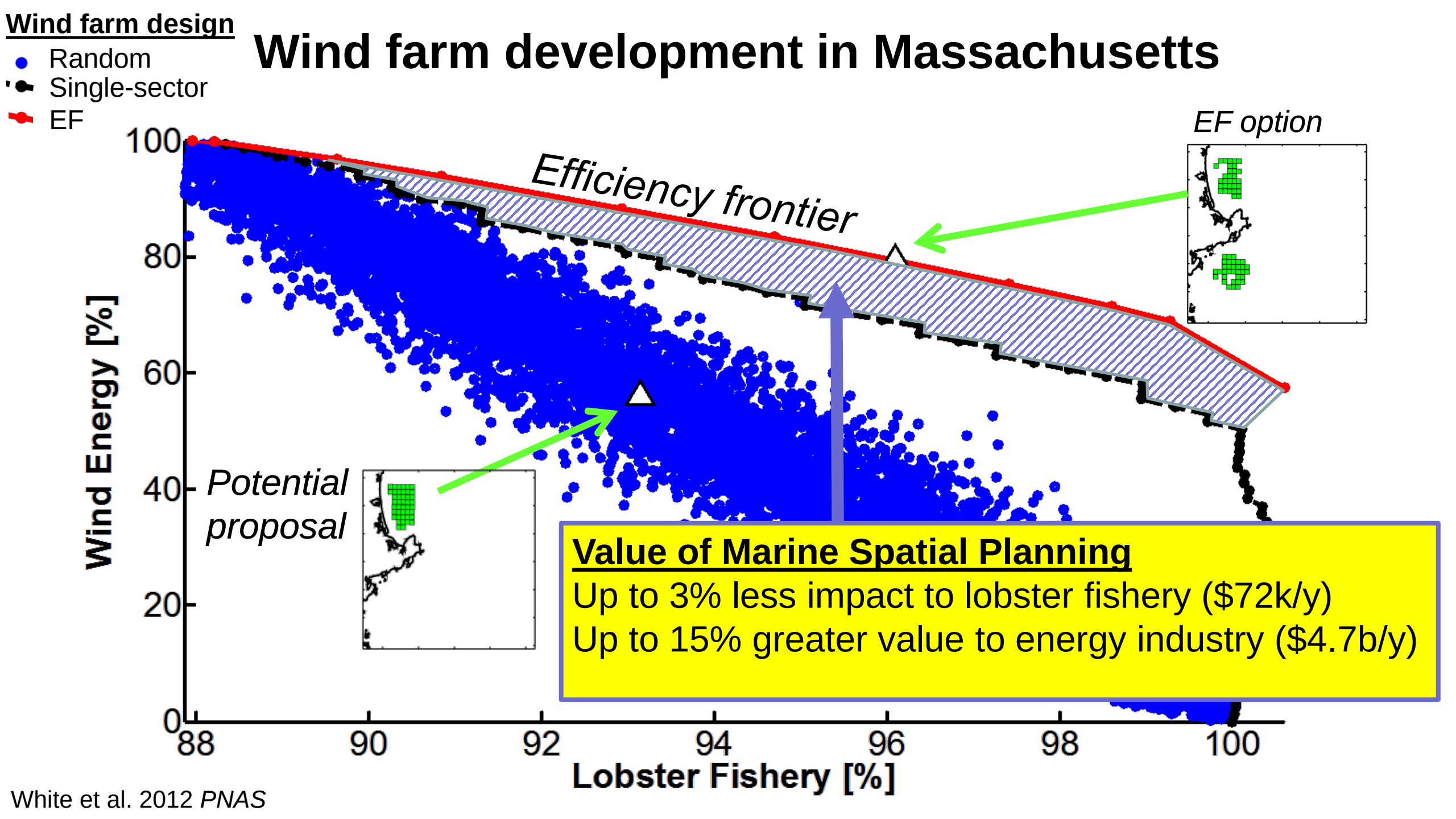


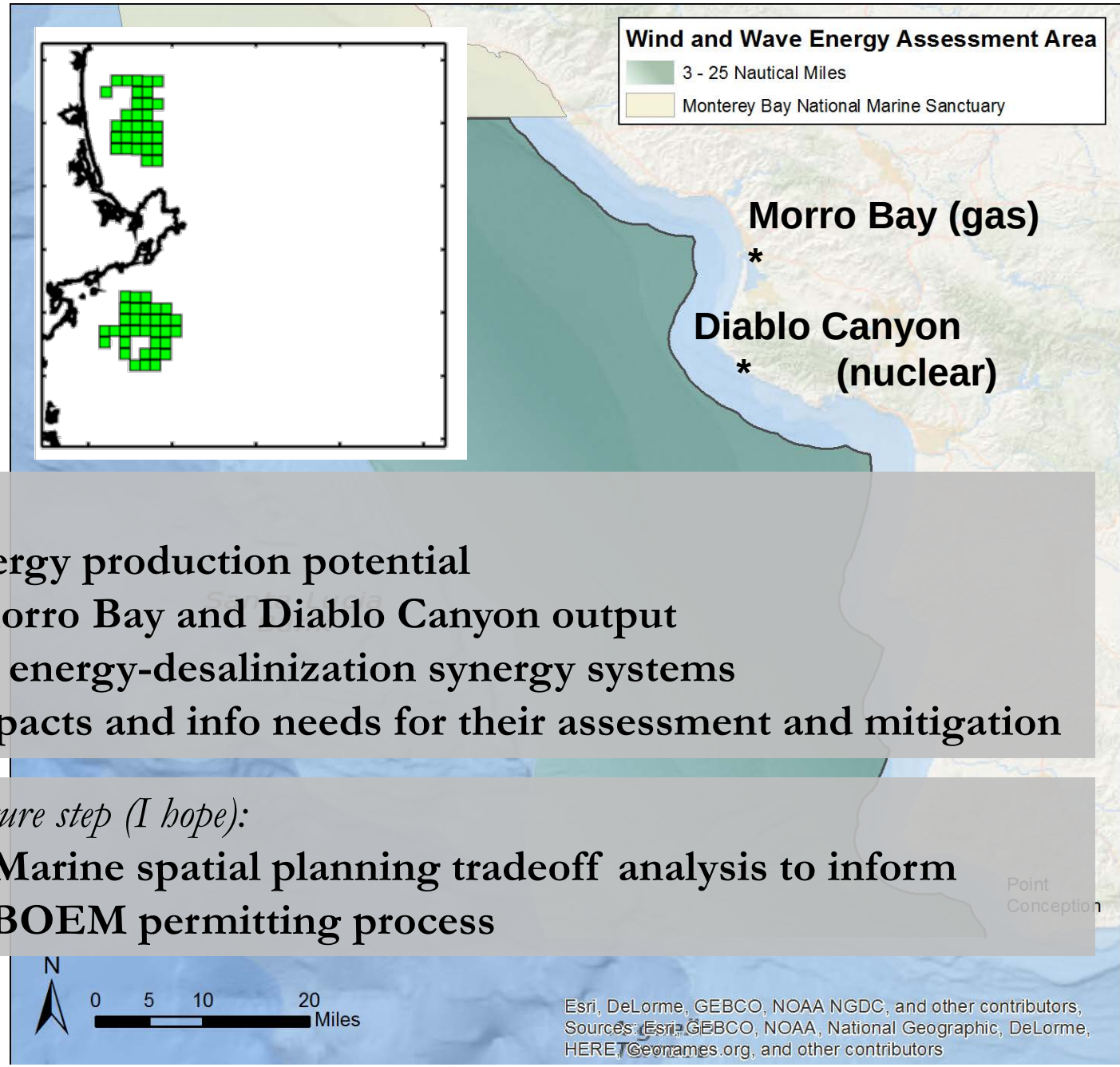
White et al. 2012 *PNAS*

A new project:

Scenarios for Replacing Conventional Energy with Offshore Renewable Energy along the Central California Coast

Ben Ruttenberg†
Crow White†
Ryan Walter†
Steve Hamilton‡
Susan Zaleski*
Donna Schroeder*
Dean Wendt†
Sam Blakeslee#

†Cal Poly Center for Coastal Marine Sciences
‡ Cal Poly Orfalea College of Business
#Cal Poly Cal Poly Institute for Advanced Technology and Public Policy
*U.S. Bureau of Ocean Energy Management



Goals (select list):

- **Assess renewable energy production potential**
  - **Compare with Morro Bay and Diablo Canyon output**
- **Explore potential for energy-desalinization synergy systems**
- **Identify potential impacts and info needs for their assessment and mitigation**

Future step (I hope):

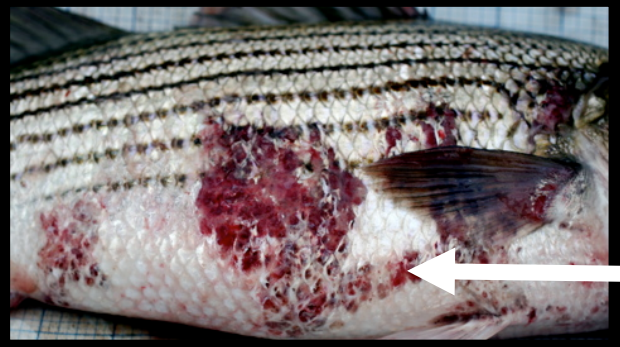
- **Marine spatial planning tradeoff analysis to inform BOEM permitting process**

Marine Spatial Planning of offshore aquaculture development in southern California

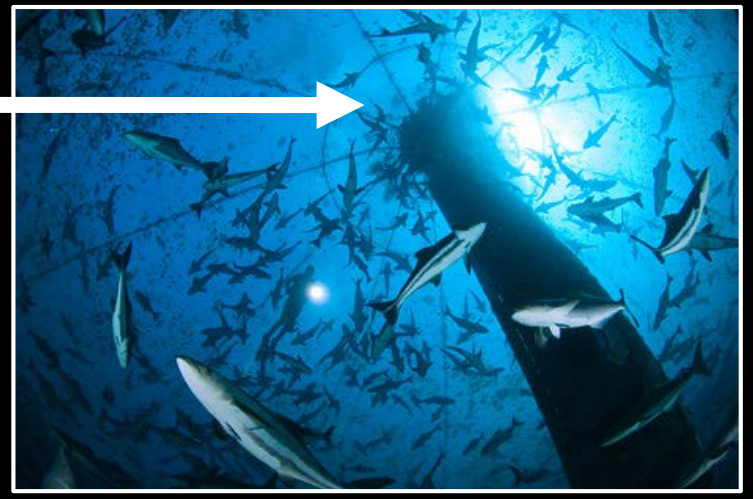
Viewshed impacts

Wild fishery

Disease risk

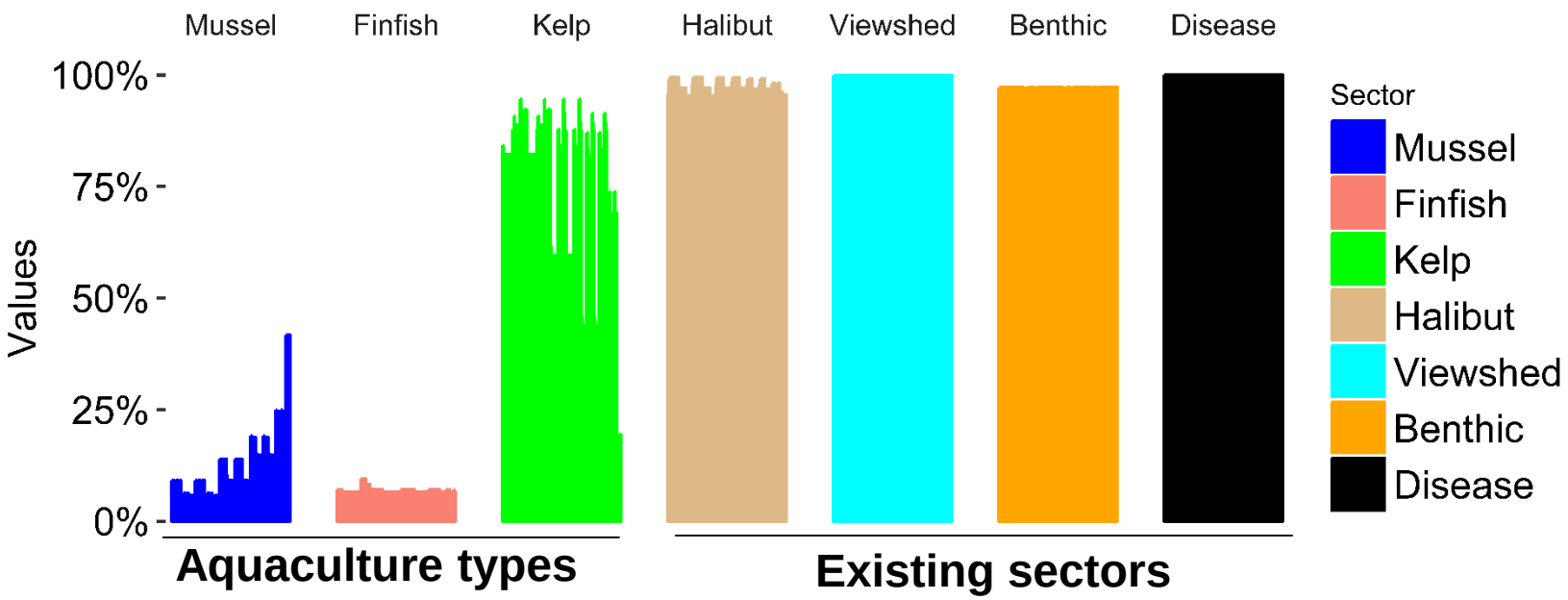


Aquaculture (3 types)



Benthic effects

242 development plans with <10% impact

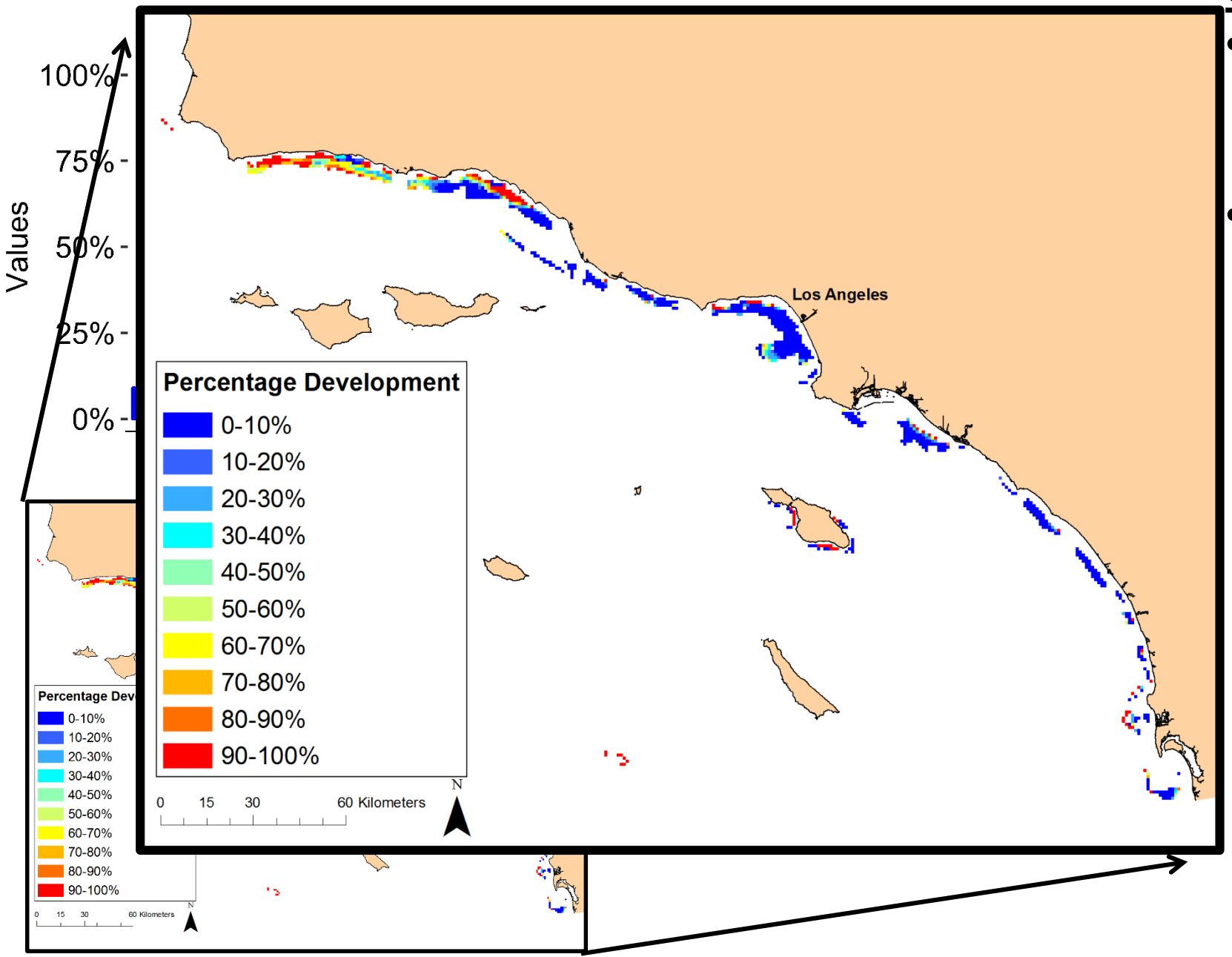


Scientific info for policy

- *How much of each aquaculture type to permit*

Stevens et al. In Review

242 development plans with <10% impact



Scientific info for policy

- *How much of each aquaculture type to permit*
- *Maps showing good places for development of each aquaculture type*

Stevens et al. In Review

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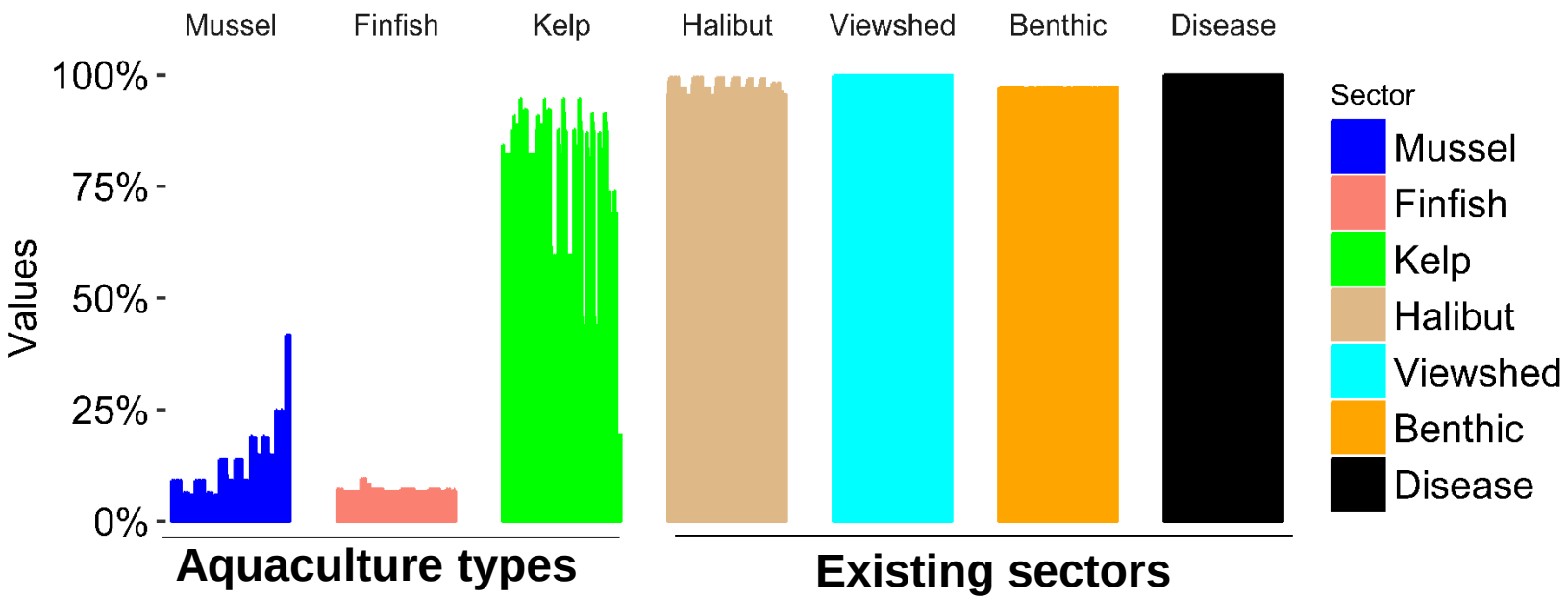

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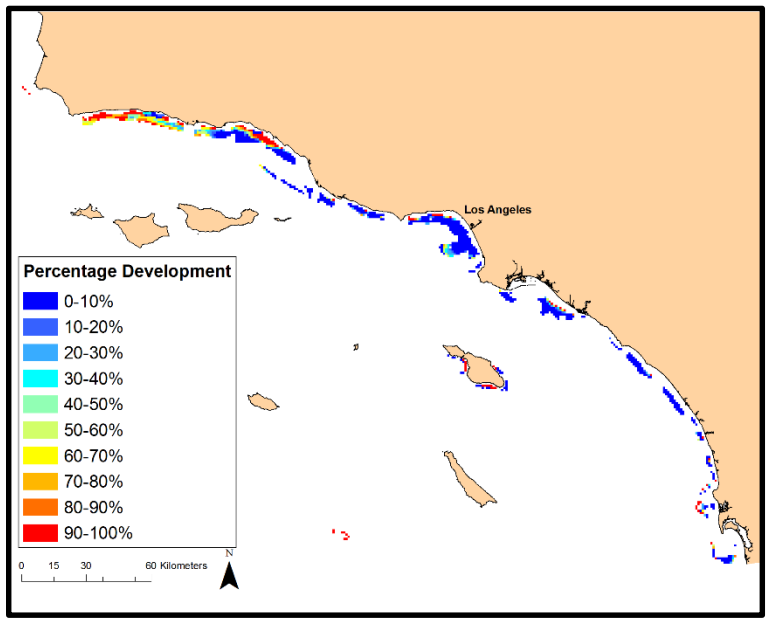

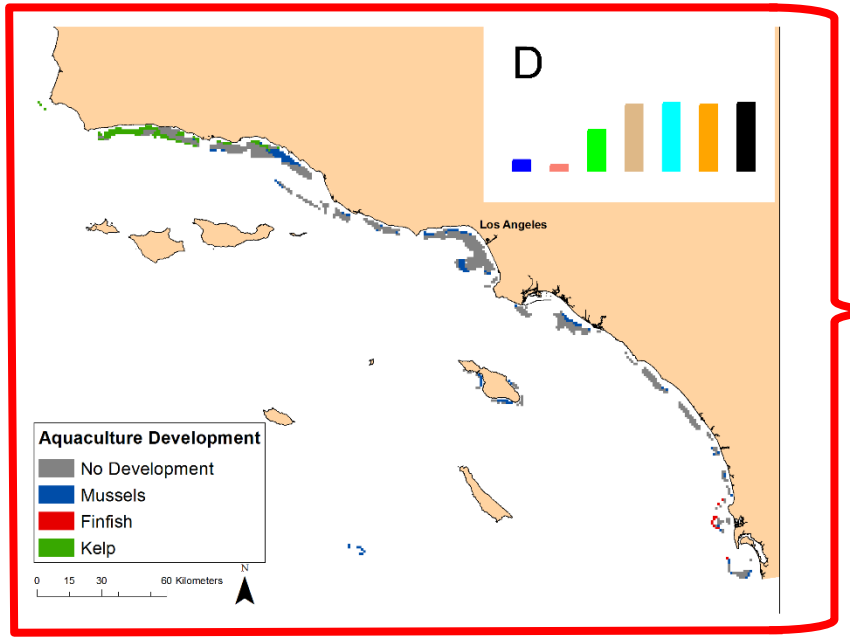

Aquaculture value of this plan:

Mussel: $800m/y

Finfish: $23m/y

Kelp: $43m/y

Stevens et al. In Review

A forward thinking approach to marine renewable energy

- **Manage conflicts and benefits**
- **Create synergies**
- **Promote ecosystem-based solutions**

- ***Collaboration among industry, science and policy***
- ***Marine spatial planning with tradeoff analysis can inform policy***
  - Flexible for considering energy alongside other ocean uses
  - Identify how much of what type of development is appropriate
  - Maps showing high-value, low-conflict areas that are good for development

Thank you!

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