Applying movement analytics to the Gulf of Mexico commercial reef fish fishery

Overview of previous work and suggestions for future research on the redistribution of fishing effort

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Talk outline

1 | What's movement analytics (and why would you do it)?

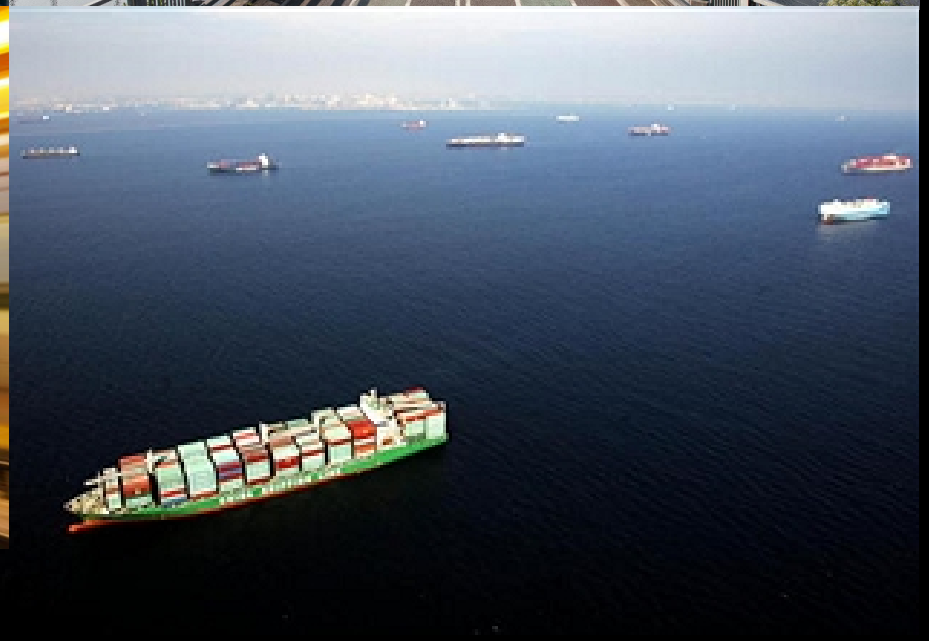
2 | How we model spatial behavior

3 | What we've learned from our previous work

4 | Gulf of Mexico reef fish studies

Discussion

1 | What's Movement Analytics?



Two broad questions:

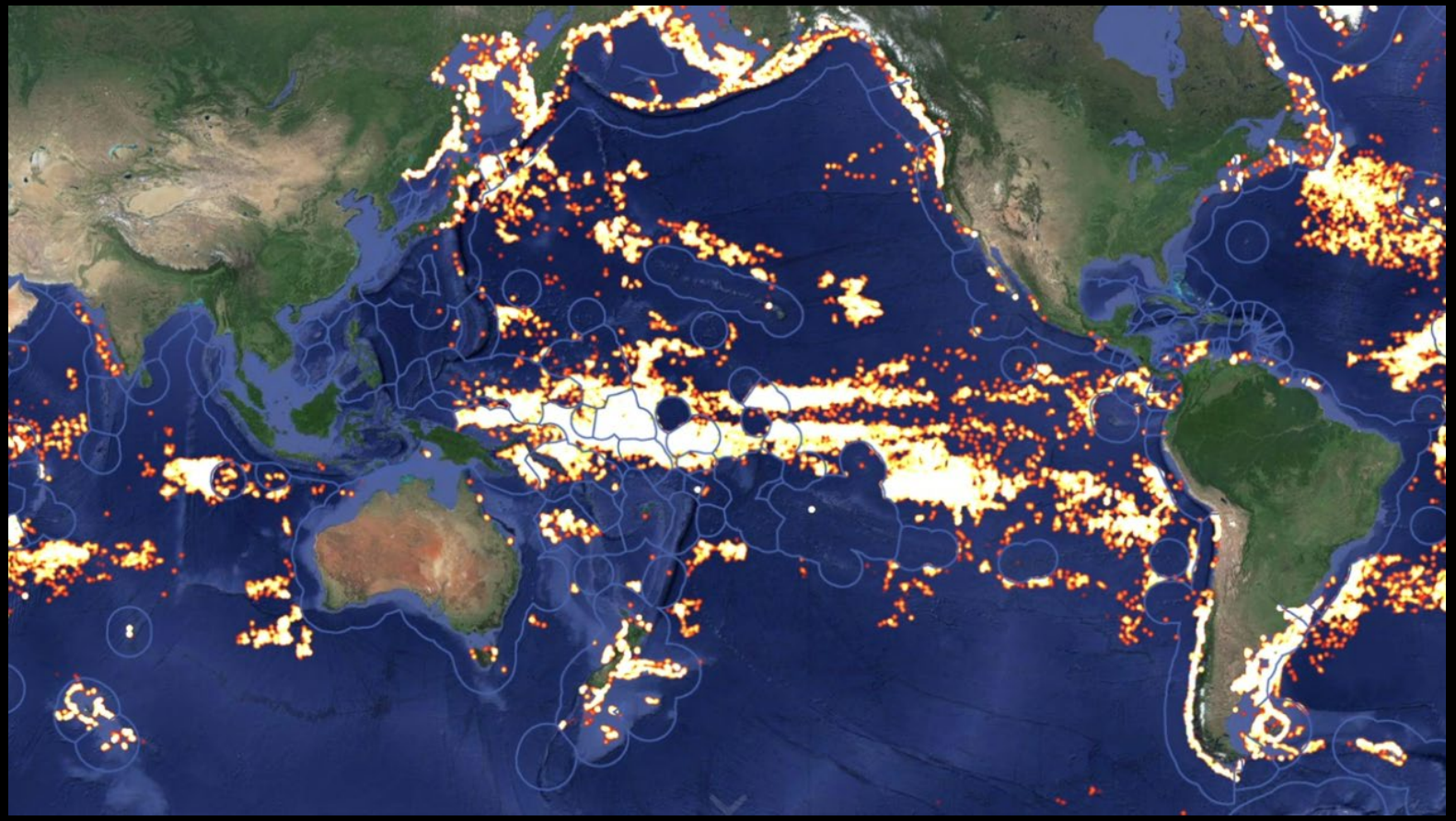
Where do people go?

(mapping spatial behaviors)

What motivates them to go there?

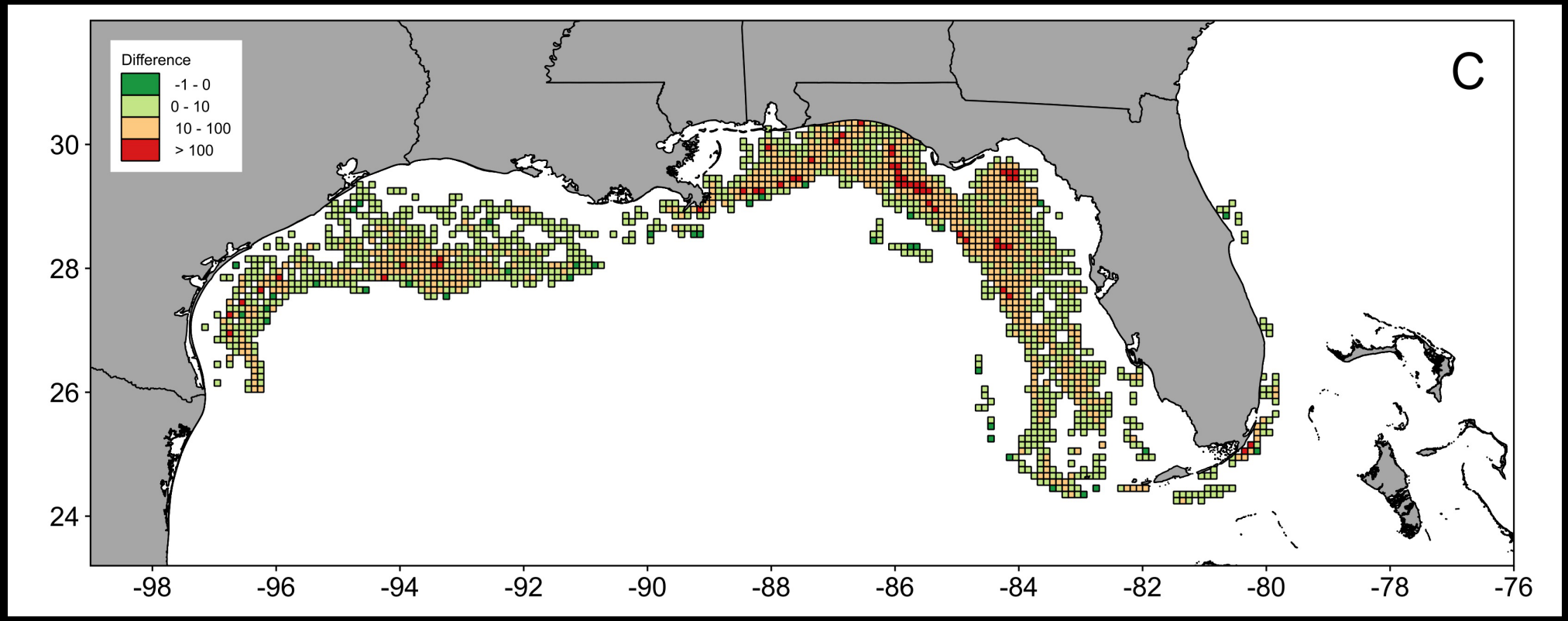
(understanding spatial behaviors… and decision-making)

A. Mapping behaviors



Global Fishing Watch image

A. Mapping behaviors



D'Farrell, Sanchirico, Chollett, Cockrell, Murawski, Watson, Haynie, Strelcheck & Perruso. 2017. "Improving detection of short-duration fishing behaviour in vessel tracks by feature engineering of training data." ICES Journal of Marine Science 74 (5)

B. Understanding behaviors

A movement track is not only a record of places visited…

…but is also a record of decisions made along the way

Normative vs empirical

B. Understanding behaviors

By working at the level of individual vessels, can we?…

Infer consistent spatial behavioral 'traits'

Predict varying vulnerability to shocks among counties or even vessels

Our datasets:

Vessel Monitoring System (VMS)

Southeast Coastal Logbook

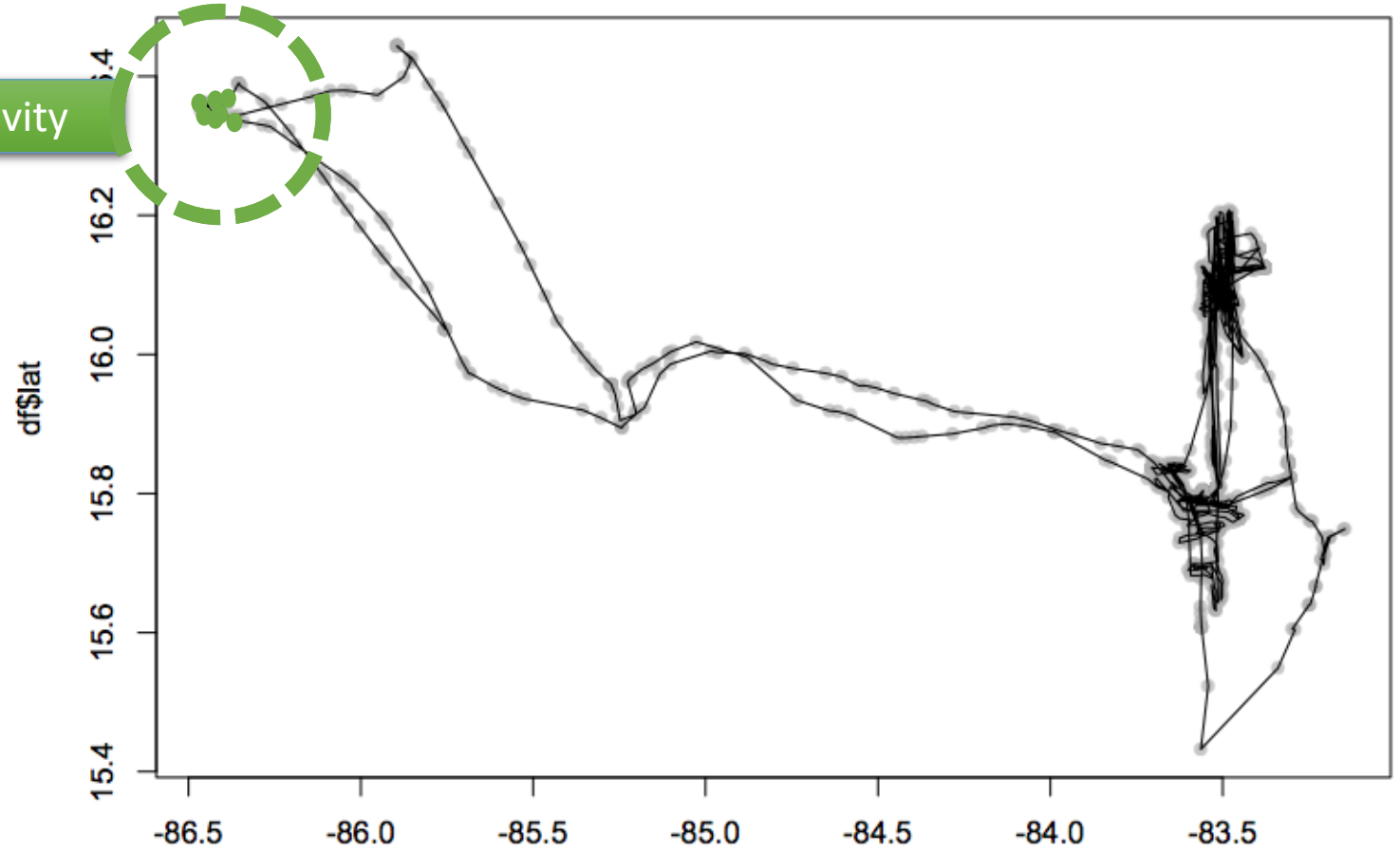
Observer records

Biophysical data (e.g., bathymetry)

2| How we model spatial behavior

VMS linked to Observer datasets

Known fishing activity



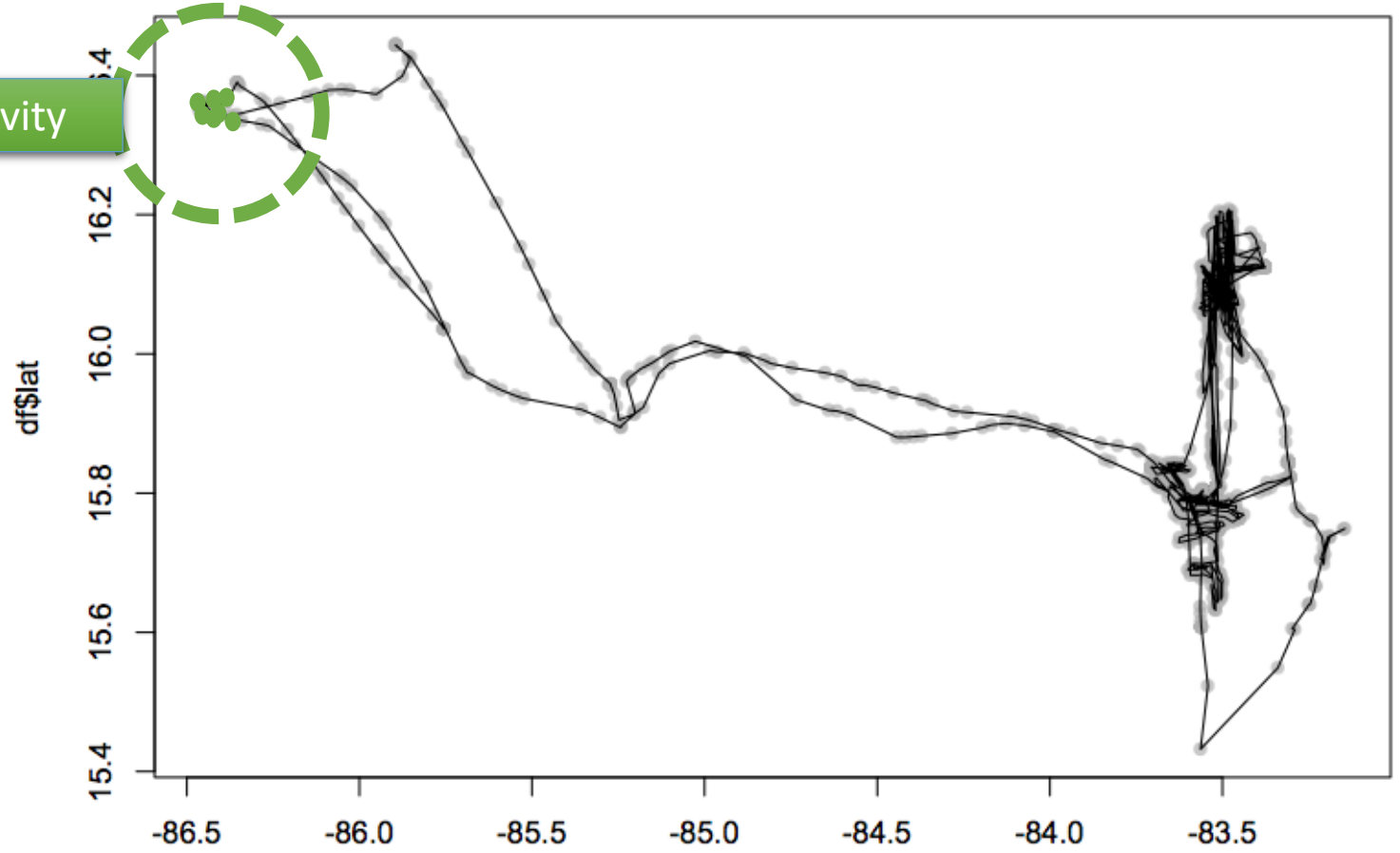
O'Farrell et al. (2017) Improving detection of short-duration fishing behaviour in vessel tracks by feature engineering of training data. *ICES Journal of Marine Science* DOI: 10.1093/icesjms/fsw244

2| How we model spatial behavior

Signature movement patterns vary by gear:

e.g., bottom longline vs bandit fishing

Known fishing activity



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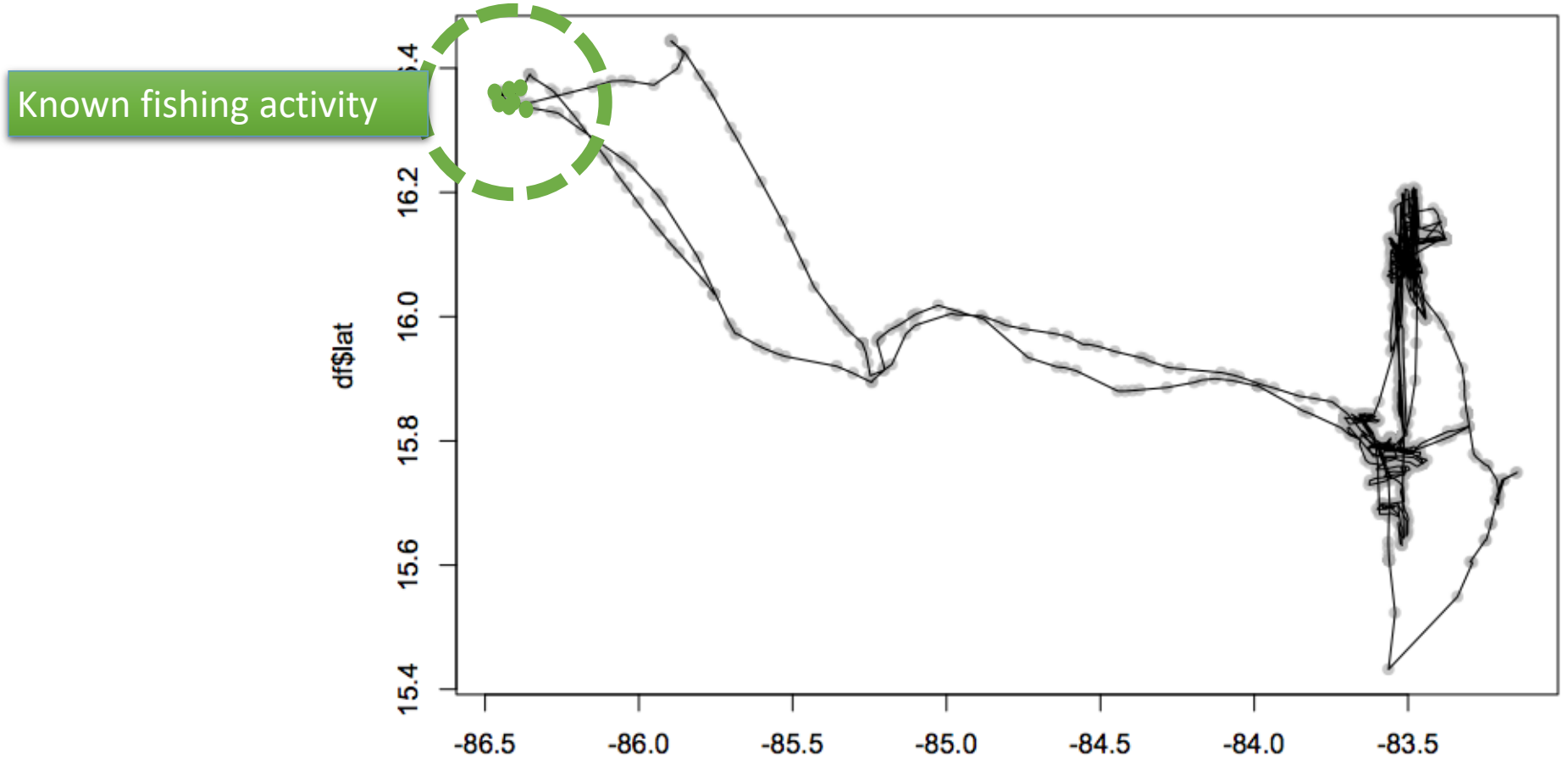
2| How we model spatial behavior

We can add a suite of other variables to the movement data, such as:

Time of day, Depth, Distance from port, Weather conditions, Fuel price etc



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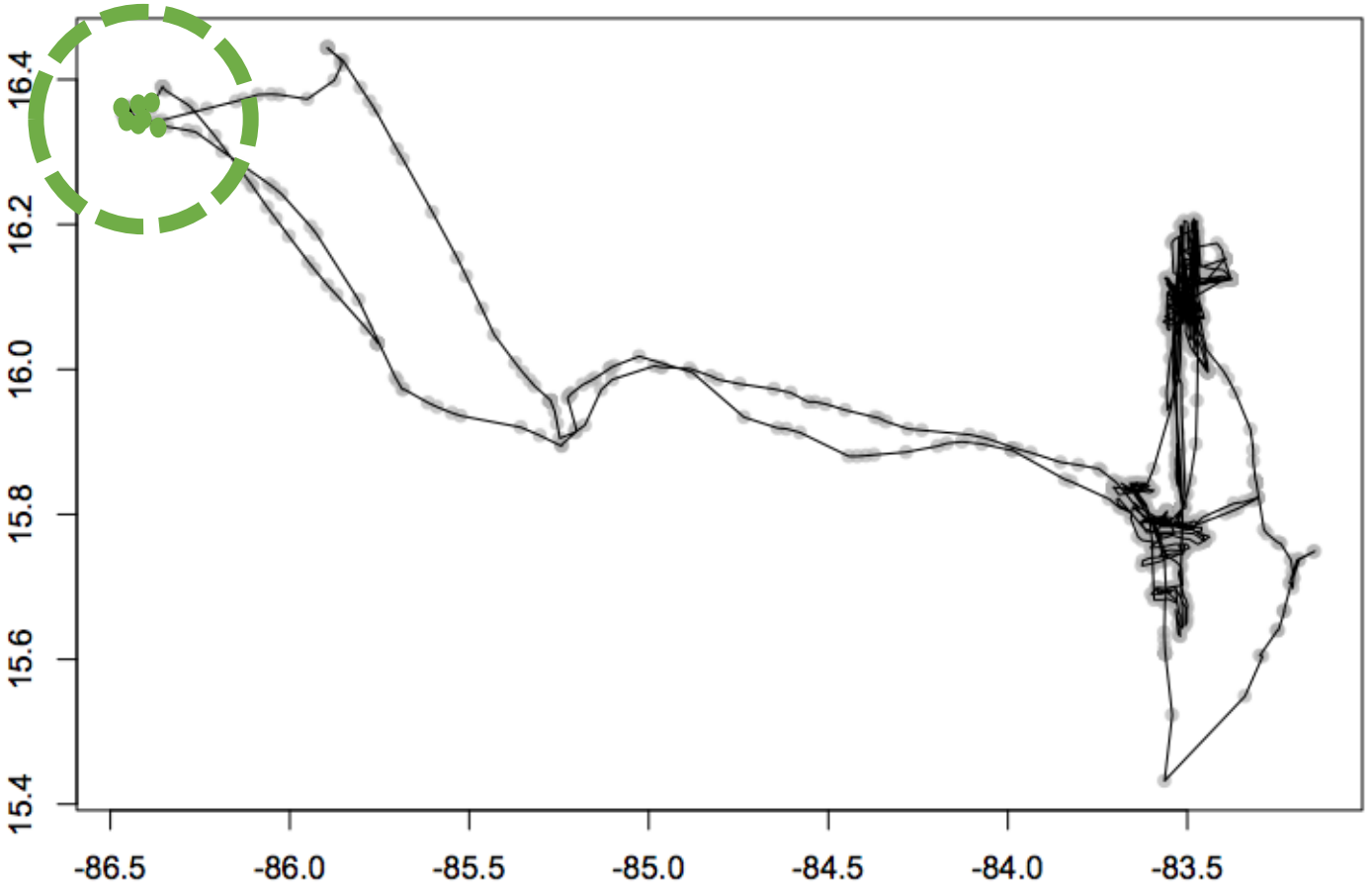
2| How we model spatial behavior



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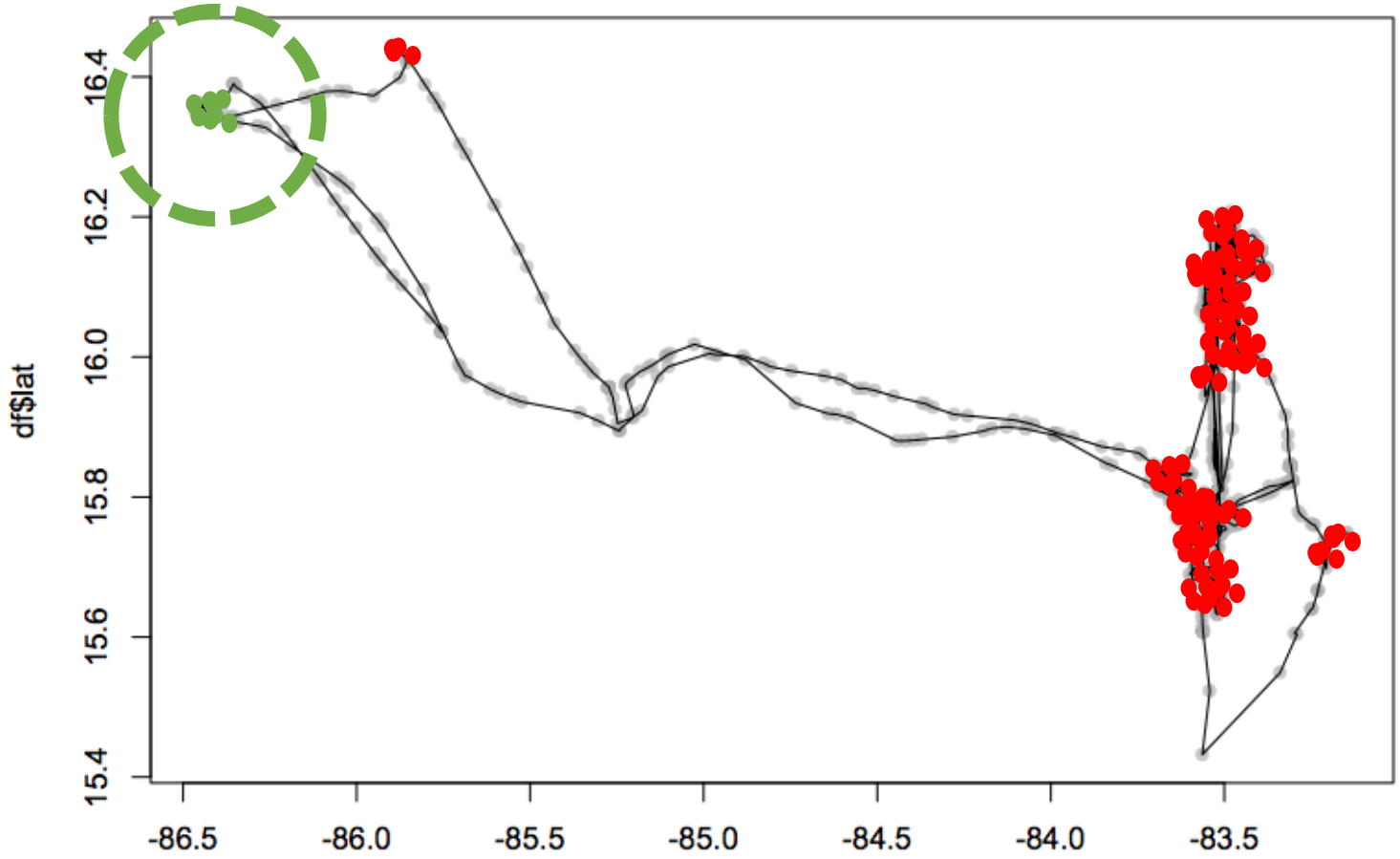

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3| What we've learned from our previous work

Now we know where and when vessels are fishing,
we can link to the logbook records …

… and start to ask questions ranging from theoretical
to applied

3| What we've learned from our previous work

All sequential decision-makers must balance the *Explore-Exploit Trade Off (EETO)*

Exploring provides new information but uncertain payoff

vs.

Exploiting provides more-certain payoff but you might do better somewhere else

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O'Farrell, Sanchirico, Spiegel, Murawski, Depalle, Haynie, Strelcheck & Perruso. 2019.

"Disturbance Modifies Payoffs in the Explore-Exploit Trade Off". *Nature Communications 10 (1)*

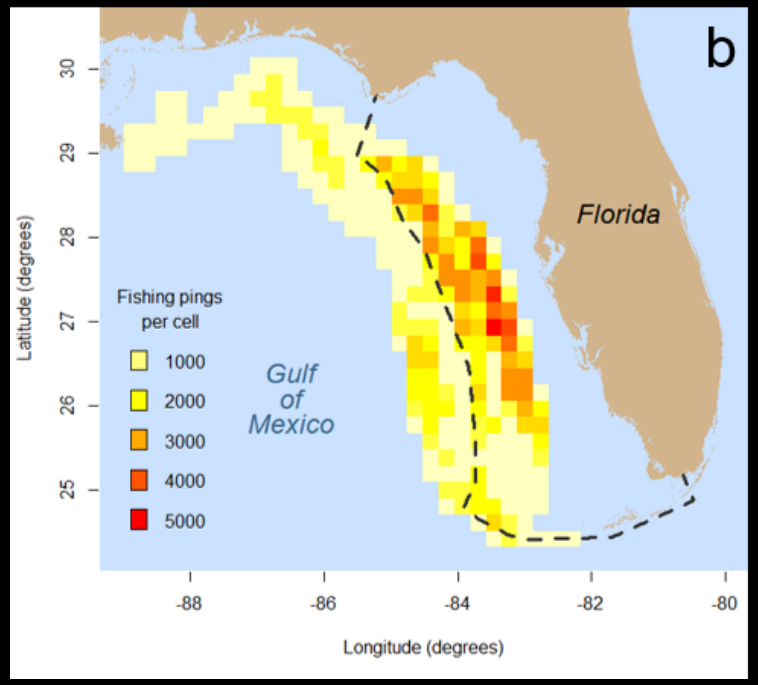
"When Taking Risks Is the Best Strategy", *Wall Street Journal,* Aug 21 2019

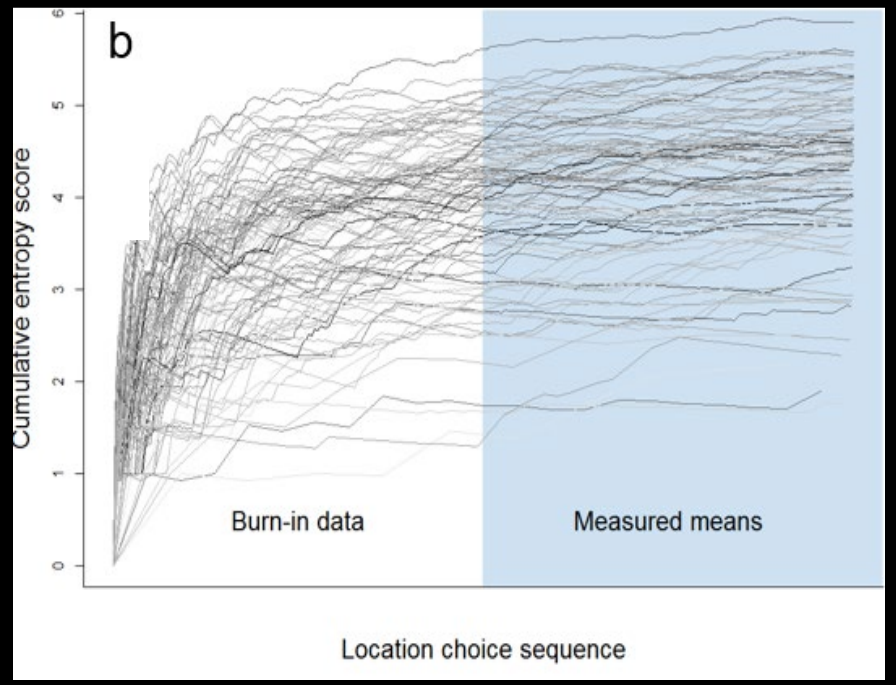
3| What we've learned from our previous work

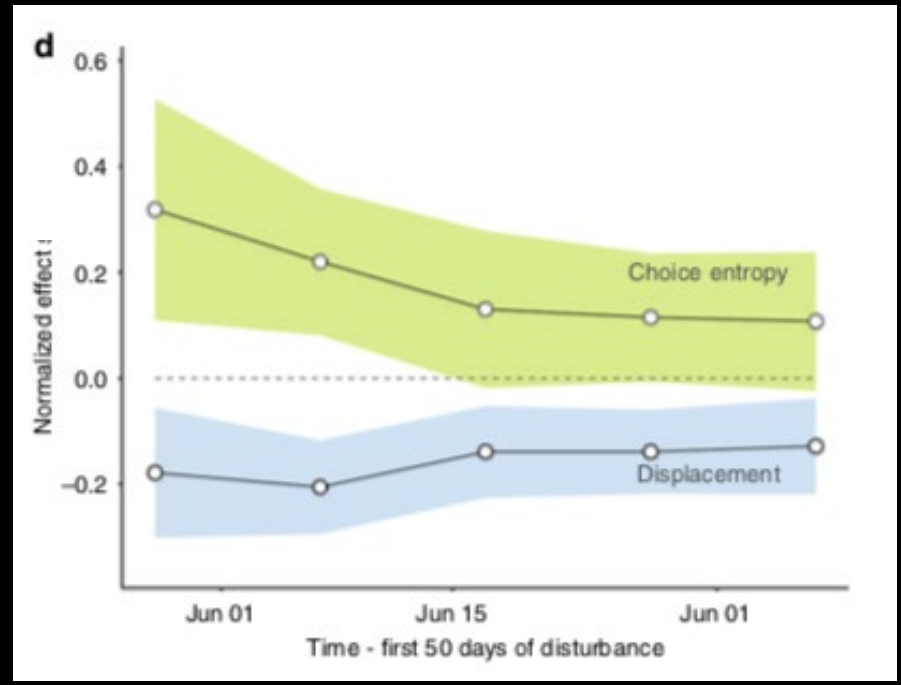
SSC motion: "The SSC encourages the SEFSC to analyze how catch level increases could impact different fishing sectors, with respect to the ability to redistribute fishing effort according to localized abundance and depletion patterns. If sufficient social and economic data are not available for these analyses, the SSC encourages the SEFSC to identify specific data gaps and needs for assessing the impacts of changes in catch limits."

However, since agents tend to vary consistently in their investment in exploration, is there a payoff?

3| What we've learned from our previous work







Investing in exploration may confer resilience to disturbance

O'Farrell, Sanchirico, Spiegel, Murawski, Depalle, Haynie, Strelcheck & Perruso. 2019.

"Disturbance Modifies Payoffs in the Explore-Exploit Trade Off". *Nature Communications 10 (1)*

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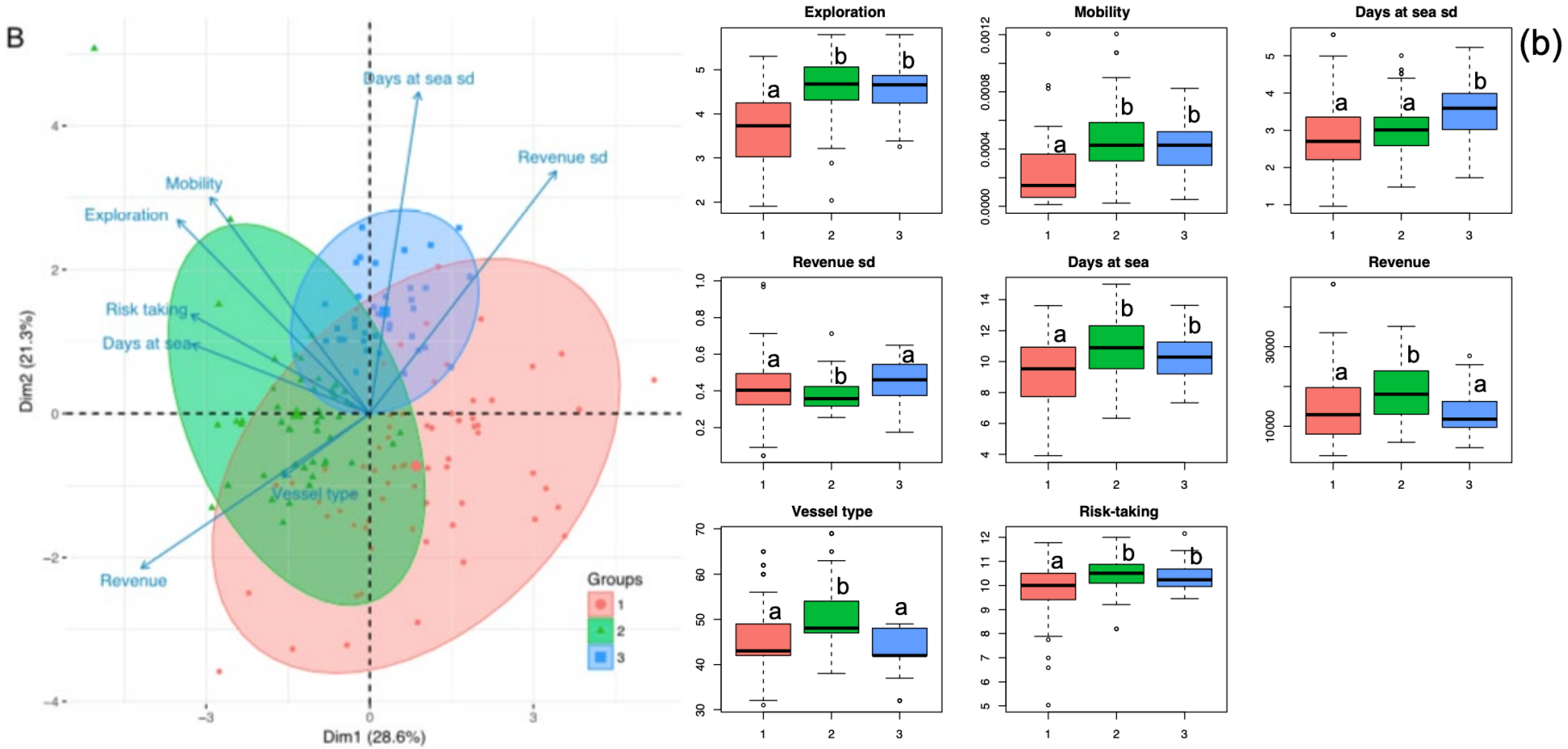
Identifying fisher behavioral types using VMS data

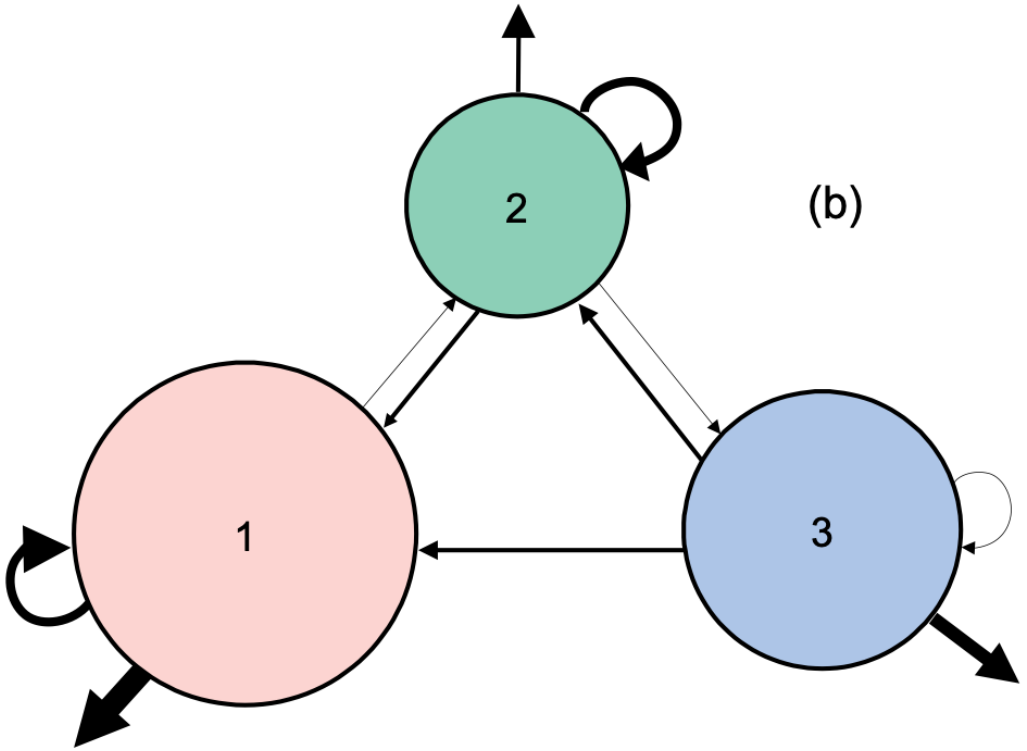


O'Farrell, Chollett, Sanchirico & Perruso. 2019. Classifying fishing behavioral diversity using high-frequency movement data. *PNAS* 116 (34)

Identifying fisher behavioral types using VMS data

PRE disturbance	POST-disturbance: EXIT	1	2	3
1	58.5	31.7	9.8	0
2	25.9	22.2	48.1	3.7
3	50.0	26.5	20.6	2.9

(a)



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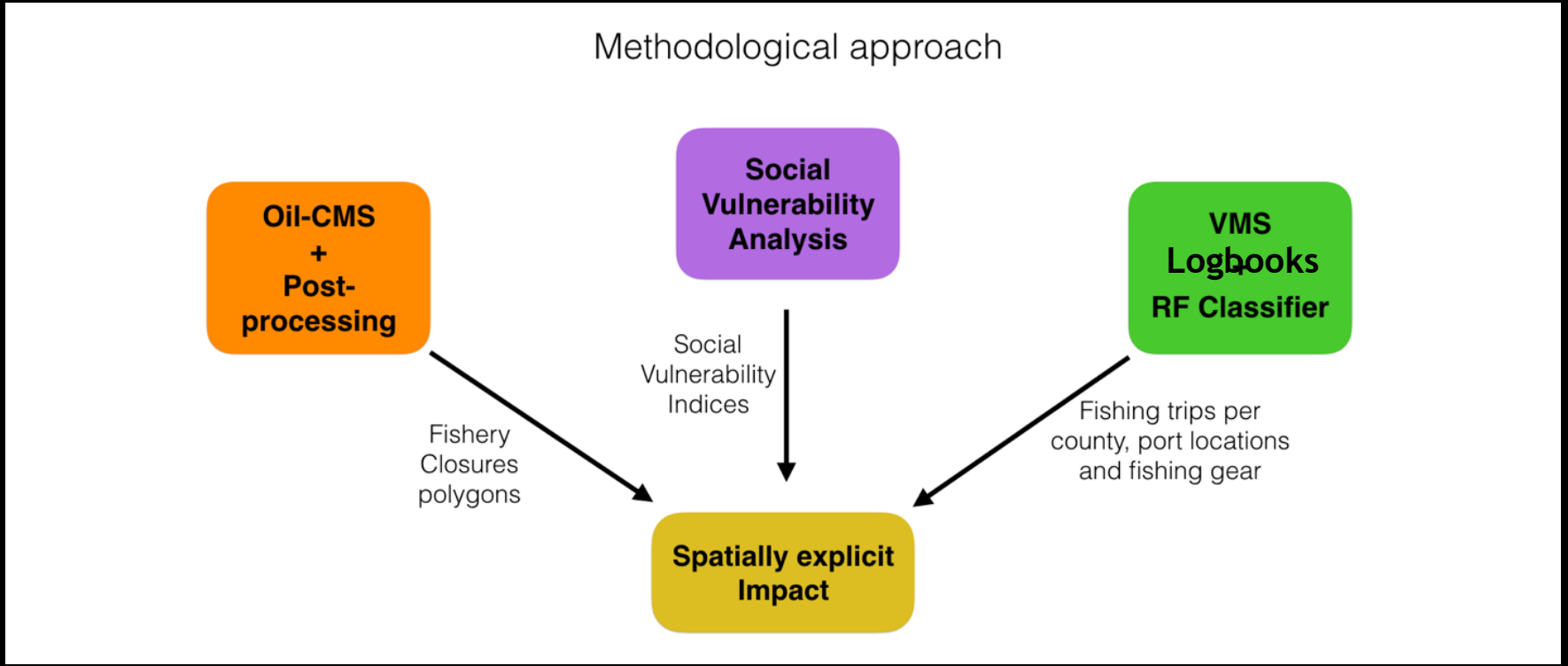
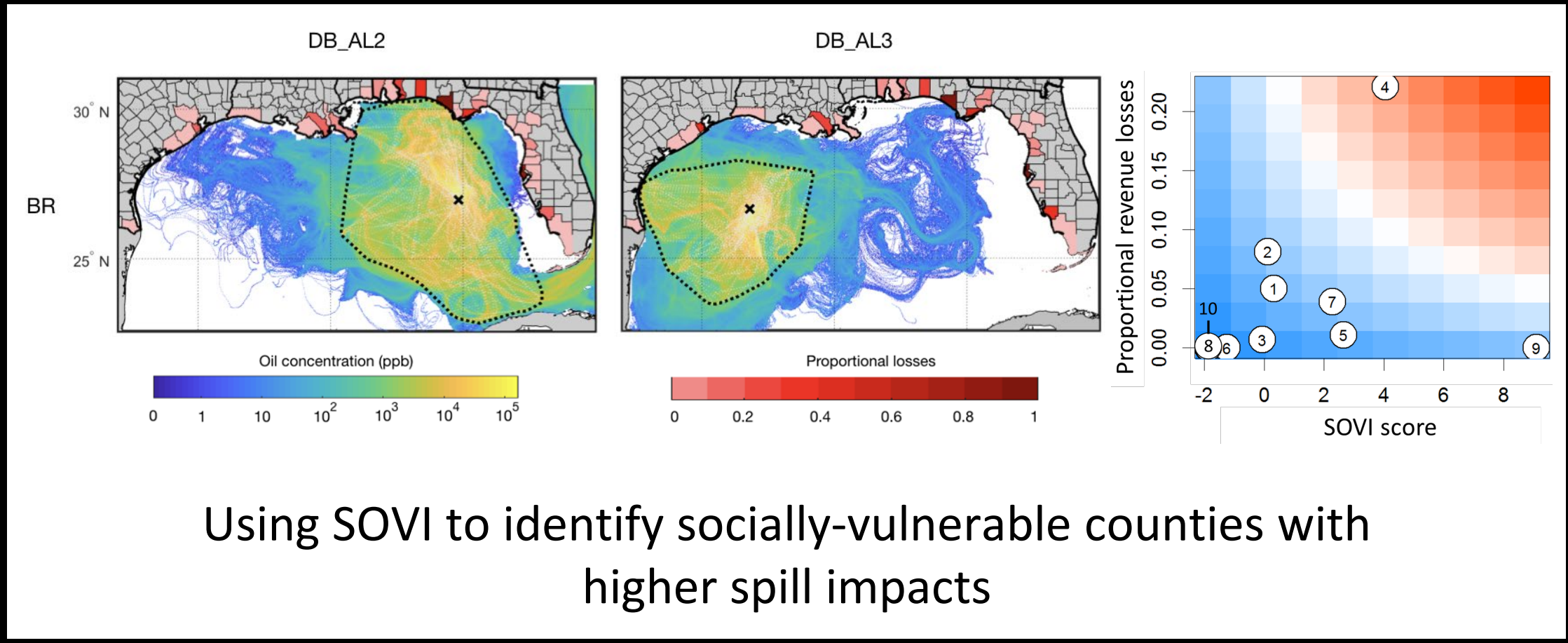
Predicting how oil-spill economic impacts differentially affect GoM counties



Berenshtein, O'Farrell, Perlin, Sanchirico, Murawski, Perruso and Paris. 2019. Predicting impacts of future oil-spill closures on fishery revenues - a spatially explicit approach. *ICES Journal of Marine Science* 76 (7)

3| What we've learned from our previous work

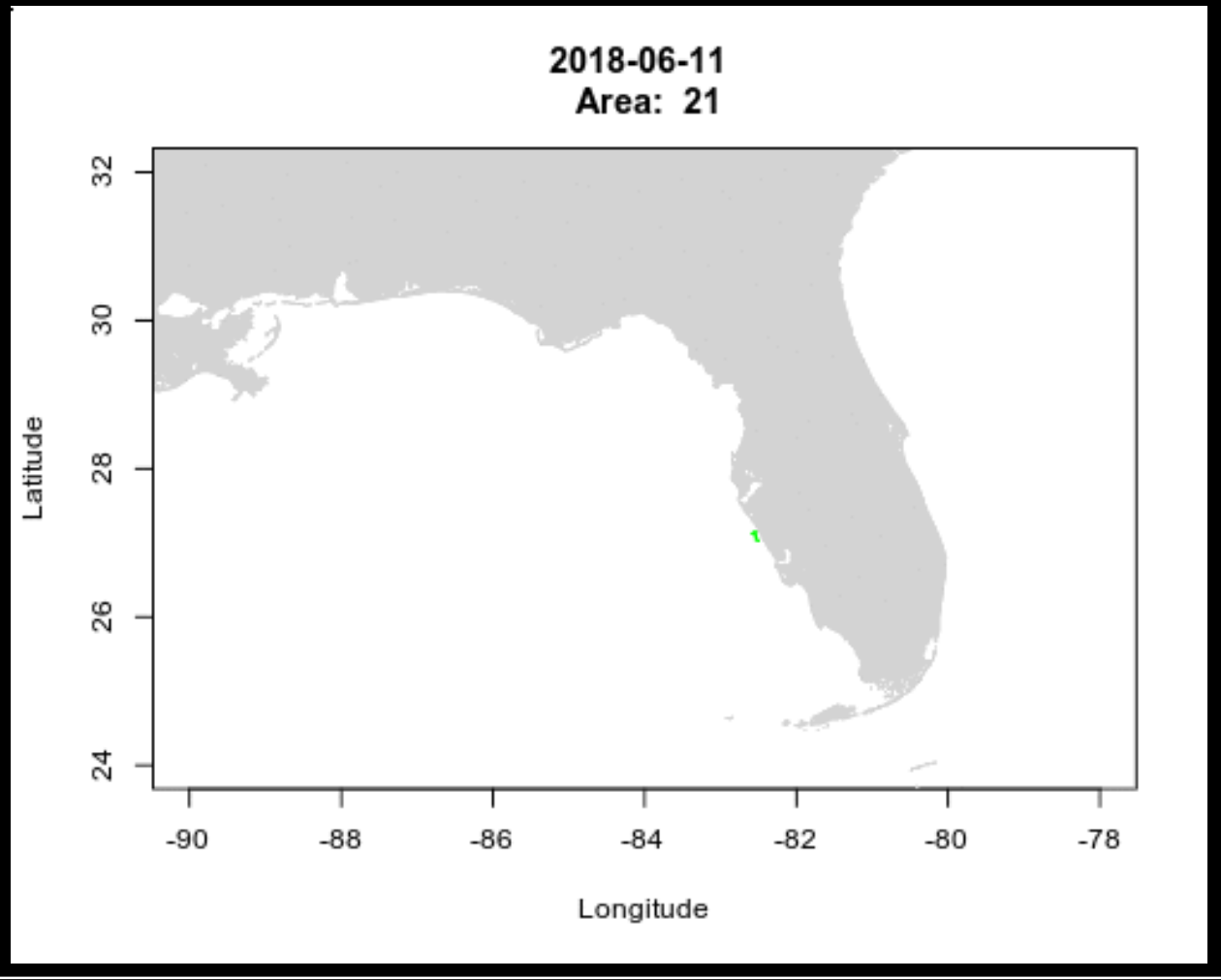


Using SOVI to identify socially-vulnerable counties with higher spill impacts

What policy options could help mitigate vulnerability?

Berenshtein, O'Farrell, Perlin, Sanchirico, Murawski, Perruso and Paris. 2019. Predicting impacts of future oil-spill closures on fishery revenues - a spatially explicit approach. *ICES Journal of Marine Science* 76 (7)

The 2018 GoM Red Tide Event



Thanks to Chuanmin Hu at U.S.F. for MODIS data

Perruso, O'Farrell, Sanchirico, Chollett. In prep. The Gulf of Mexico commercial reef-fish fishery during the 2018 red tide event.

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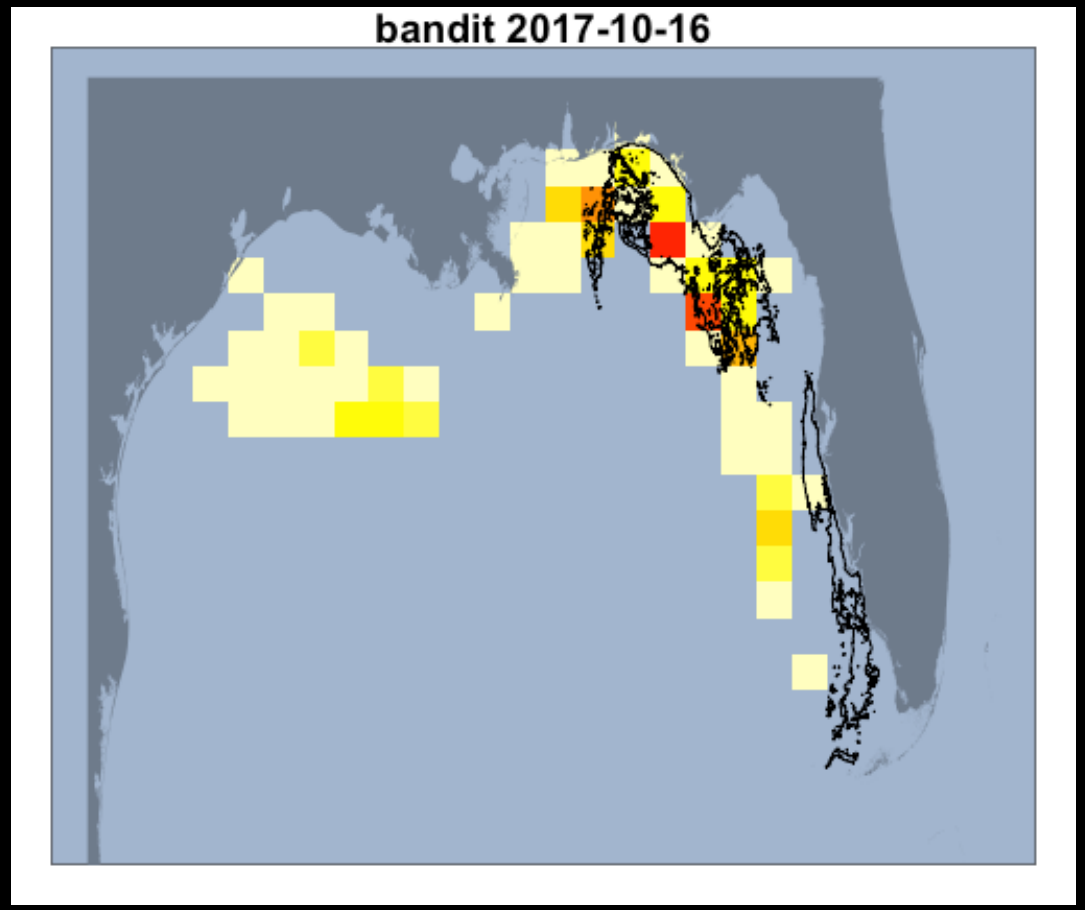

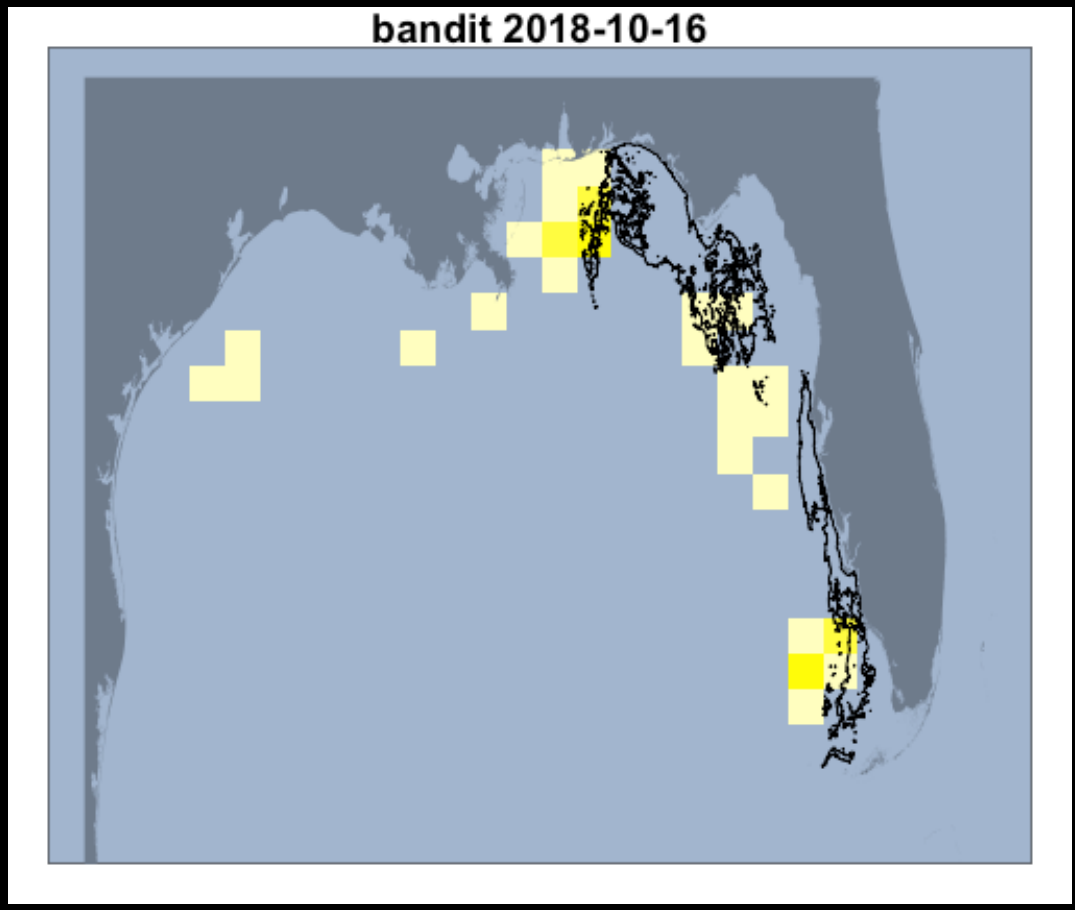

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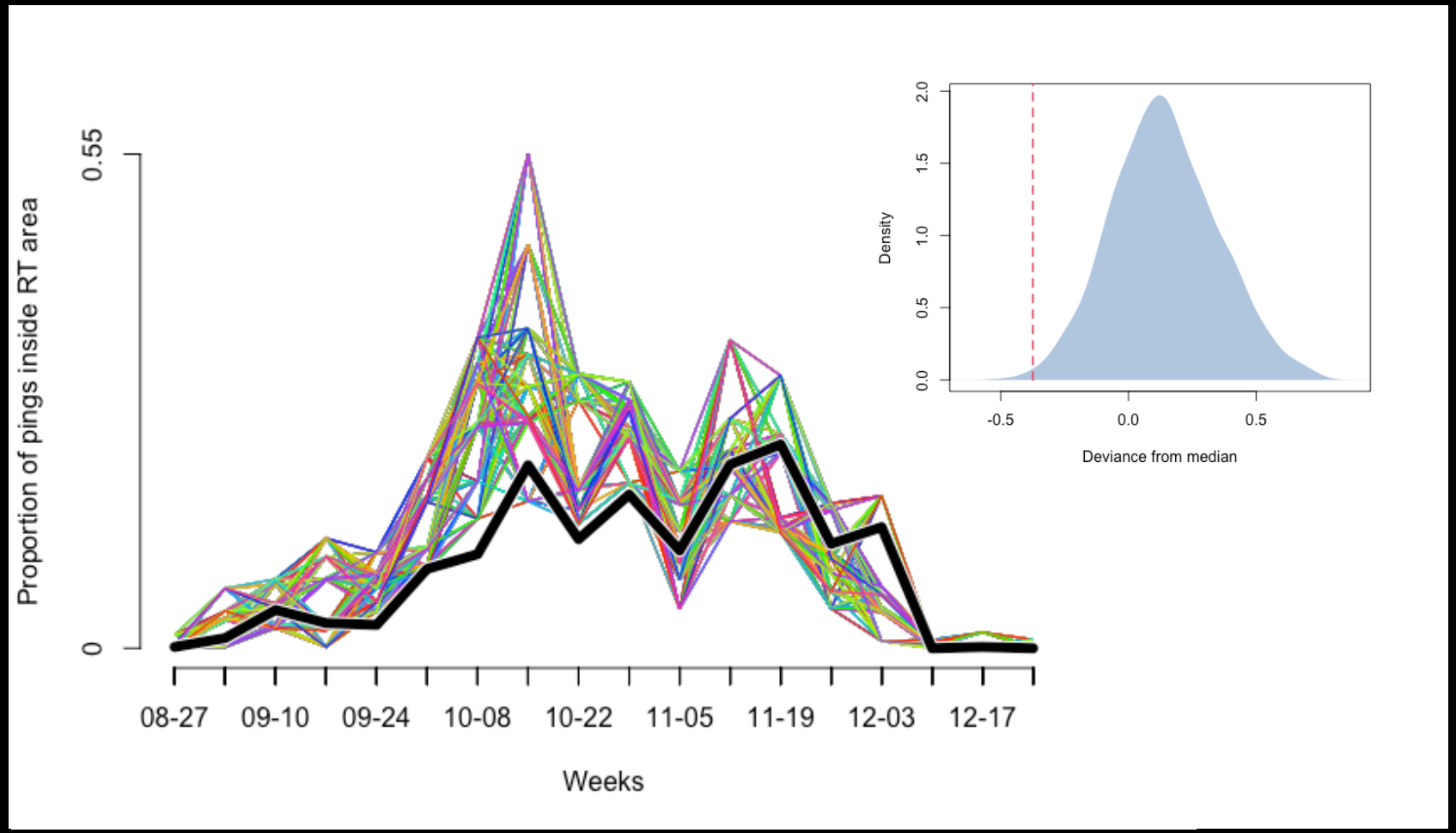
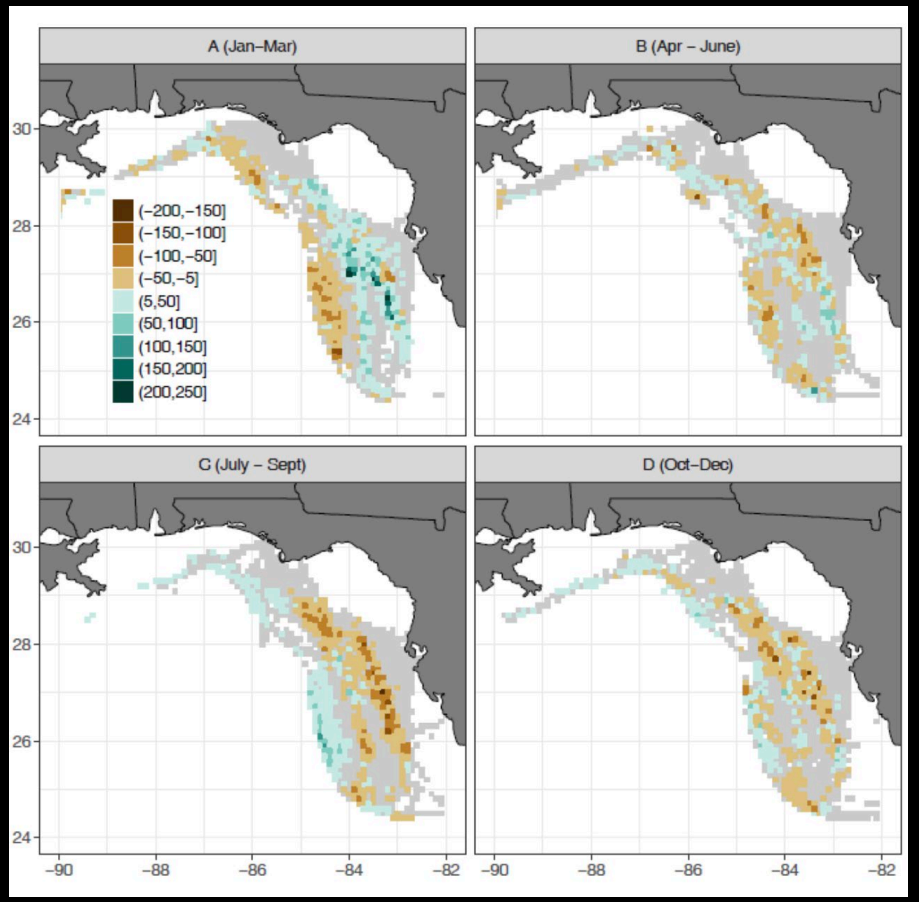


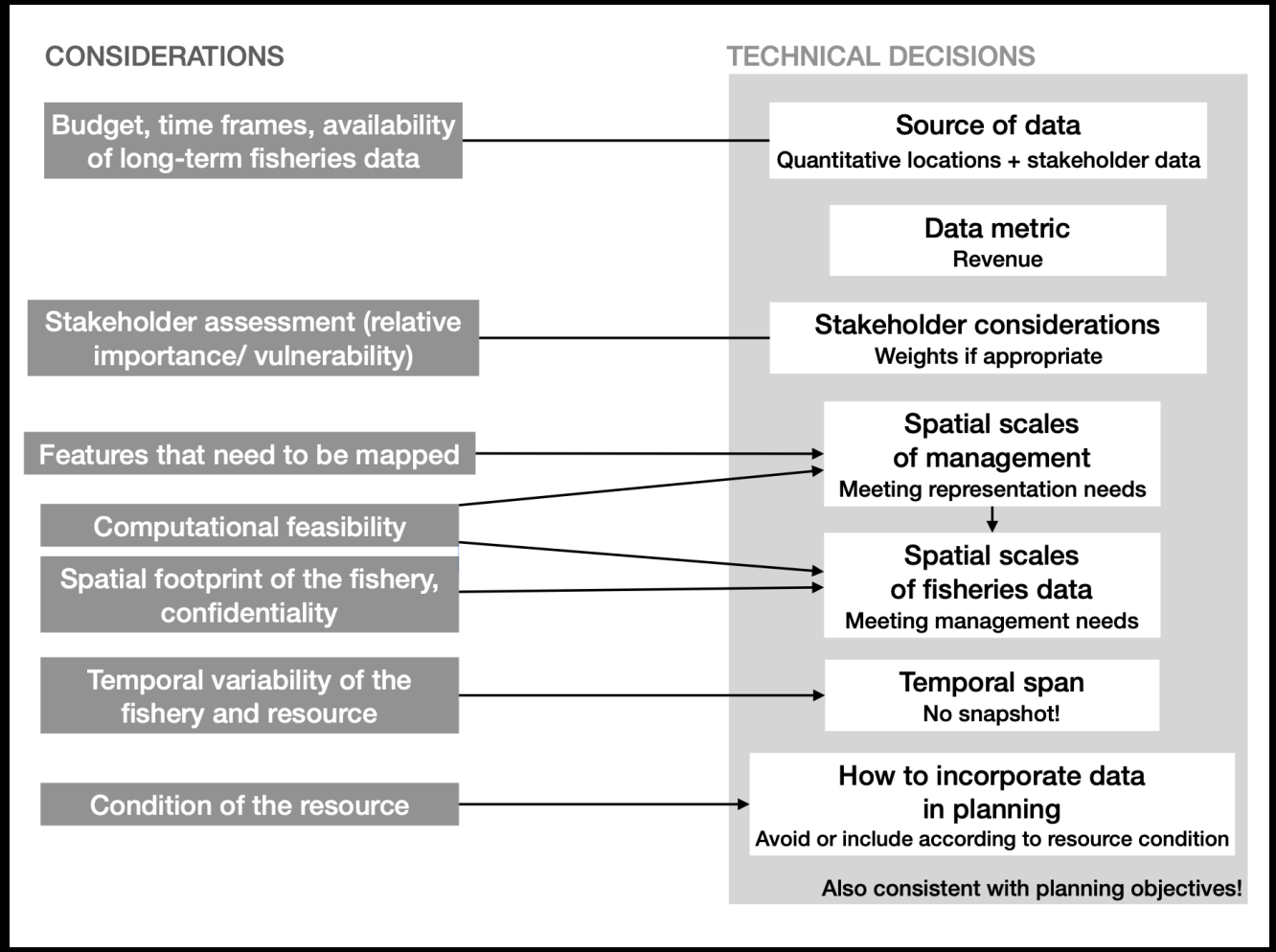
Perruso, O'Farrell, Sanchirico, Chollett. In prep. The Gulf of Mexico commercial reef-fish fishery during the 2018 red tide event.

Fisheries responses to individual fishing quotas



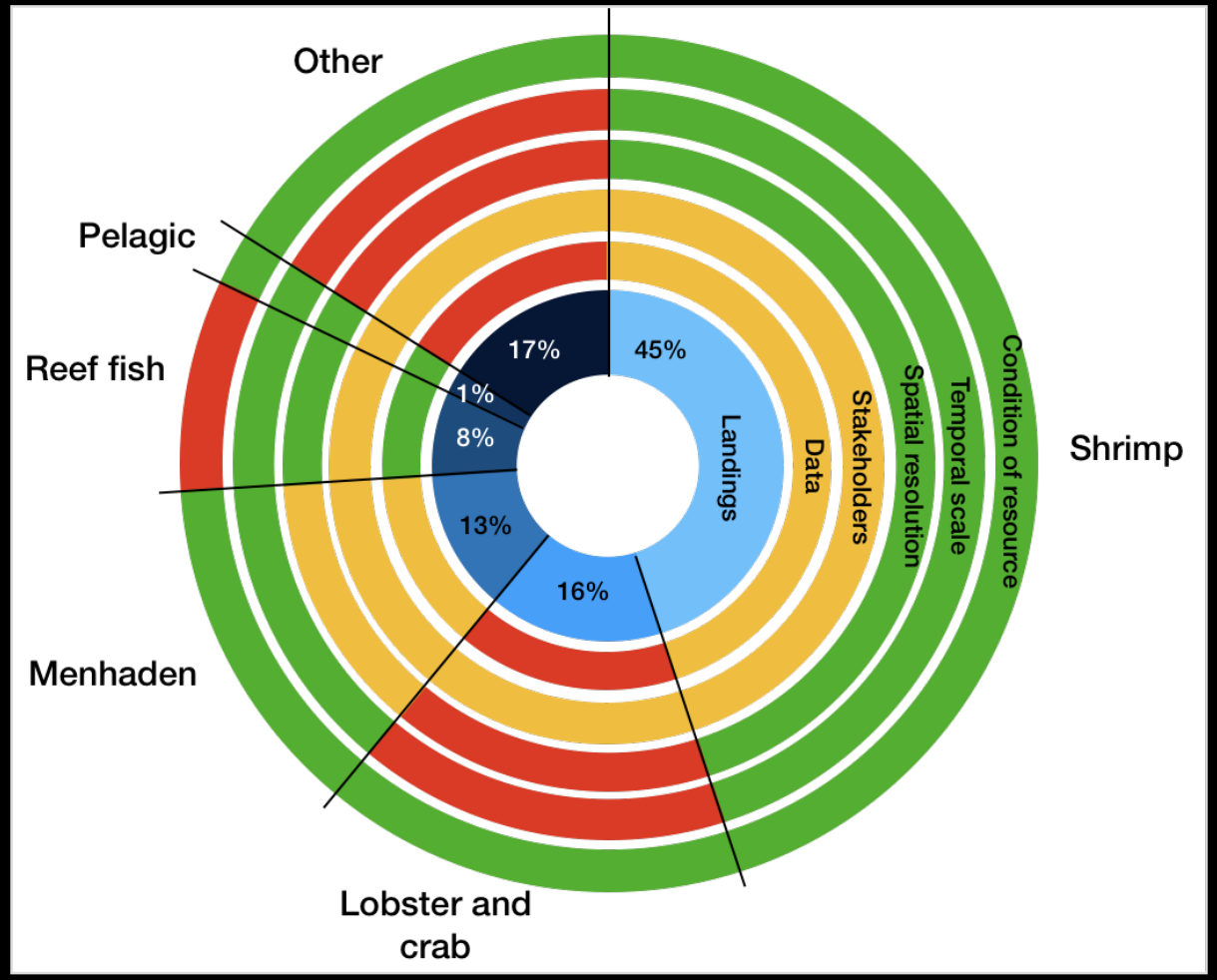
Watson, Haynie, Sullivan, Perruso, O'Farrell, Sanchirico, Mueter. 2018. VMS reveal an increase in fishing efficiency following regulatory changes in a demersal longline fishery. Fisheries Research. 207:85-94.

Using fisheries data for spatial planning



Chollett, Perruso, O'Farrell. In prep. Towards a better use of fisheries data in spatial planning

Data needs for spatial planning in the GoM



Perruso, Chollett, O'Farrell. In prep. Commercial fisheries data needs for better marine spatial planning in the Gulf of Mexico

4 | Other applications in the Gulf of Mexico

- Economic displacement due to oil spills and regulations
- Fine-scale observation of effort and depletion on artificial structures and other habitat
- Scale dependency of fishing locations in discrete choice behavioral models
- Identifying fishing effort for site mapping of offshore aquaculture and wind farms

Any questions?

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