A GREATER GRAY

ECOLOGICAL CONNECTIVITY AT GRAY'S REEF NATIONAL MARINE SANCTUARY

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I INTRODUCTION

Gray's Reef National Marine Sanctuary (GRNMS), off the coast of Georgia, is one of the smallest National Marine Sanctuaries, at only 57 square km in size. As one of the few natural, protected areas of "live-bottom" reef in the Carolinian Ecoregion (**Figure 1, Inset**), Gray's Reef has tremendous ecological importance as a spawning ground and habitat for many of the marine species in the region.

Human pressures such as overfishing have led to population declines for several economically important fish species living in and around the Sanctuary. To offset these human impacts, managers are interested in exploring options for effective management that will aid these species at the Sanctuary and beyond.

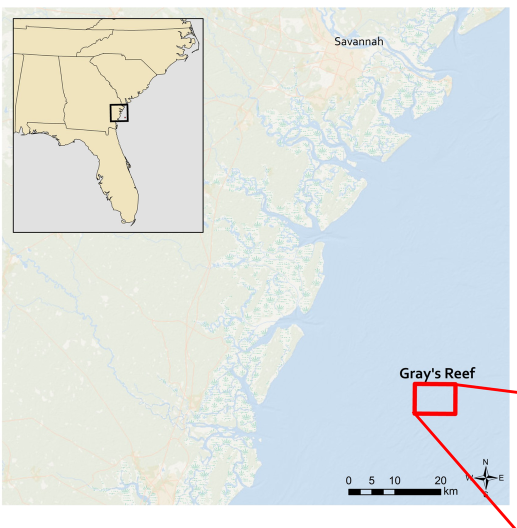


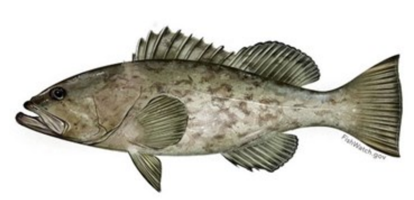
Figure 1. Gray's Reef in the context of the United States. Inset shows live-bottom reef at GRNMS.

This project will identify possible areas for protection that have a strong, demonstrated ecological connection to GRNMS, benefiting fish populations at the Sanctuary and in the ecoregion as a whole. To find important areas that act as sources of juvenile fish for GRNMS, we modeled ecological connectivity using larval movements in the ocean. This will help locate areas that contribute high quantities of fish larvae to Gray's Reef, and identify where further protection would help replenish populations at the Sanctuary.

II APPROACH

We selected four focal species within the Snapper-Grouper complex, a group of fish species that faces heavy fishing pressure in the Carolinian Ecoregion. These fish represent the diverse populations at Gray's Reef because they display differing life histories, have all experienced overfishing, and are all economically important to the area:

Black Sea Bass

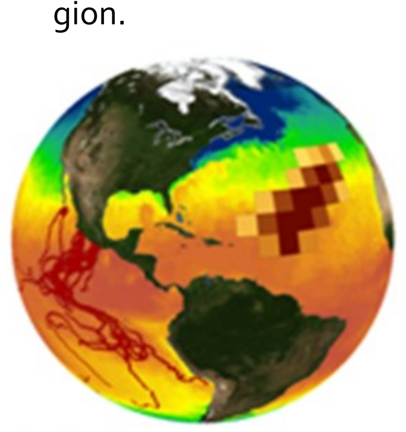


Gag Grouper

Red Snapper

Scamp Grouper

Ecological connectivity was then modeled, using larval movement, to understand how juvenile fish ultimately arrive at GRNMS. Because larval movement is not subject to many of the same pressures as their adult counterparts, the modelling of larval transport is an excellent way to understand marine ecological connectivity. Juvenile fish recruitment can be boosted at GRNMS by using ocean currents to predict larval transport from other reefs in the region.



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Modeling was performed using MGET - Marine Geospatial Ecological Tools, a GIS-based model. We modeled four species each month during their peak spawning from 2009 to 2015, completing over 400 model runs.

MGET uses daily oceanographic currents data, known spawning locations, and other species-specific parameters to track larval movement through the region after a spawning event.

III FINDINGS

As our four species are all long-lived, we chose to address variation over time by modelling for the seven years of available data. Although there are also variations between species, we can see that similar trends in connectivity exist for all species. This allows us to identify areas that would simultaneously benefit all four species in the region.

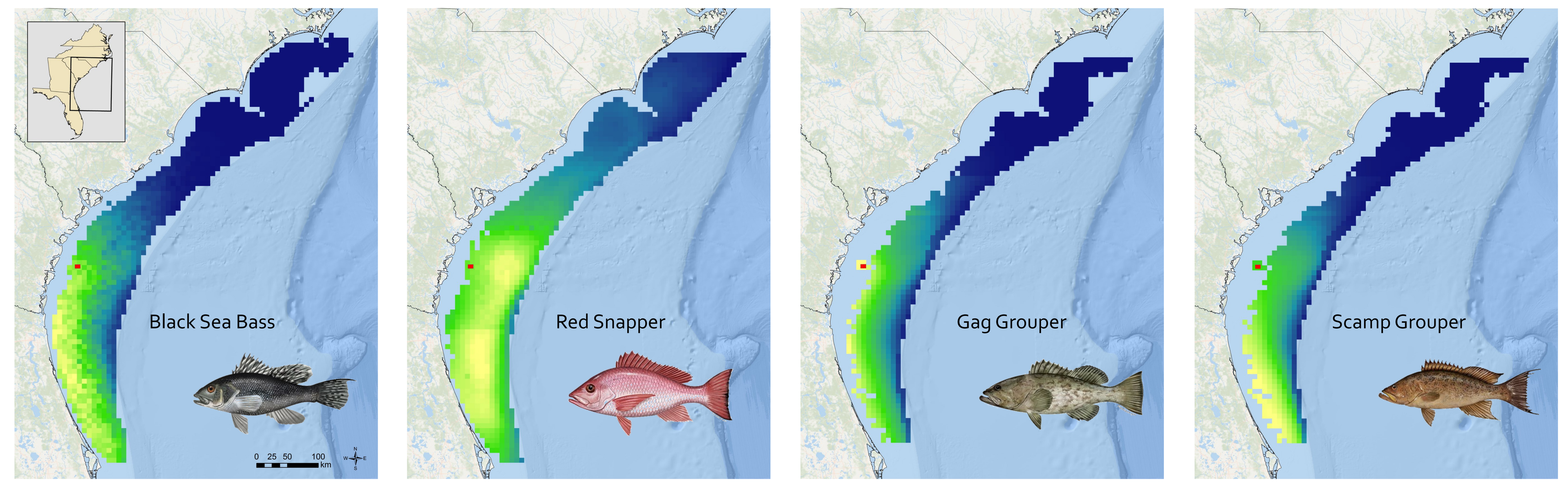

Figure 2. Model results for the four species from 2009-2015. These maps show the percent of larvae donated from each 8x8 km. cell within the study area that contributes to Gray's Reef, for each of the four species of interest. The red box indicates the location of Gray's Reef. These maps illustrate areas that donate larvae to Grays reef and are colored to represent areas that contribute the highest (yellow), medium (green), and lowest (blue) amount of larvae to GRNMS. The total larvae quantity contributed to Gray's Reef is normalized to 100%.

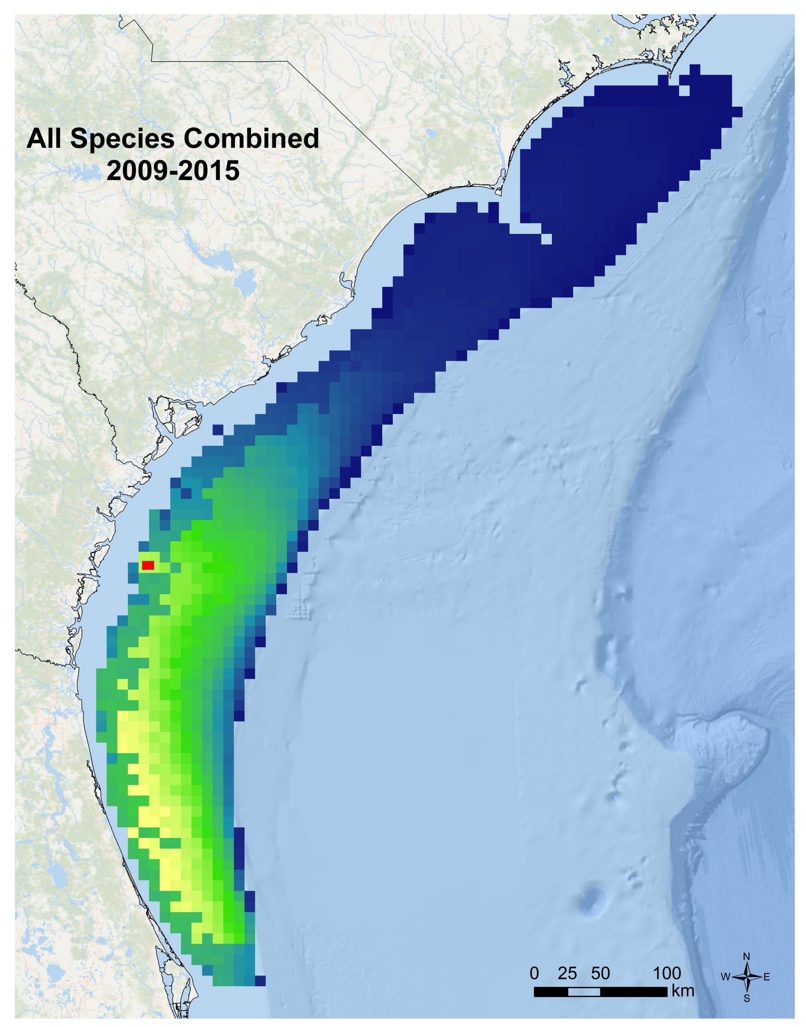

Figure 3. All Species Aggregated Map for the four species from 2009-2015. The red box indicates the location of Gray's Reef, and the lighter color areas (more yellow) indicate higher larval contribution to Gray's Reef.

Results for each individual species were aggregated, across spawning month from 2009 – 2015 (**Figure 2**). To find areas for possible conservation that would benefit all species combined, the results for each individual species were aggregated (**Figure 3**). When looking at each of the four species individually, as well as collectively, our results demonstrate that areas of strongest ecological connectivity and highest larval contribution to GRNM are those areas south of the sanctuary off the Georgia and Florida coast.

Although the results for each individual species differ slightly, there are consistent aspects in the areas of strongest connectivity, and therefore a clear opportunity to choose sites that benefit all four species, despite their differences. Because black sea bass, red snapper, and scamp and gag grouper are representative of reef fish at the sanctuary, these results provide an understanding of connectivity for a range of reef species at GRNMS.

IV CONCLUSIONS

To better understand the management implications, our results were converted to illustrate the minimum area that must be conserved to protect a given percentage of larval contribution (**Figure 4**). Additionally, an area curve converts target larval percentages in these highlighted areas into square kilometers, which gives managers a better understanding of the spatial implications of these findings (**Figure 5**).

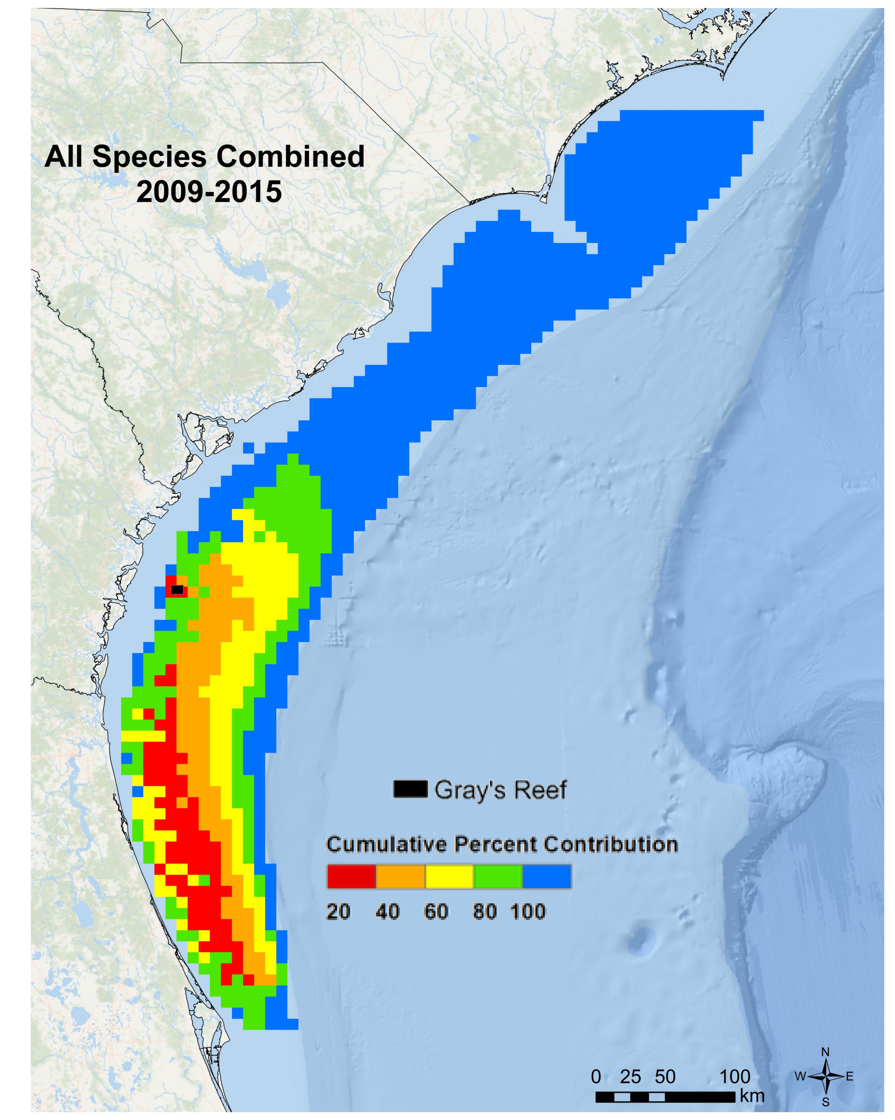

Figure 4. All Species Cumulative Percent Larval Contribution, 2009-2015. Protecting the yellow area will conserve 20% of the total fish larvae. Protecting both the yellow and light green area will conserve 40%, and so on.

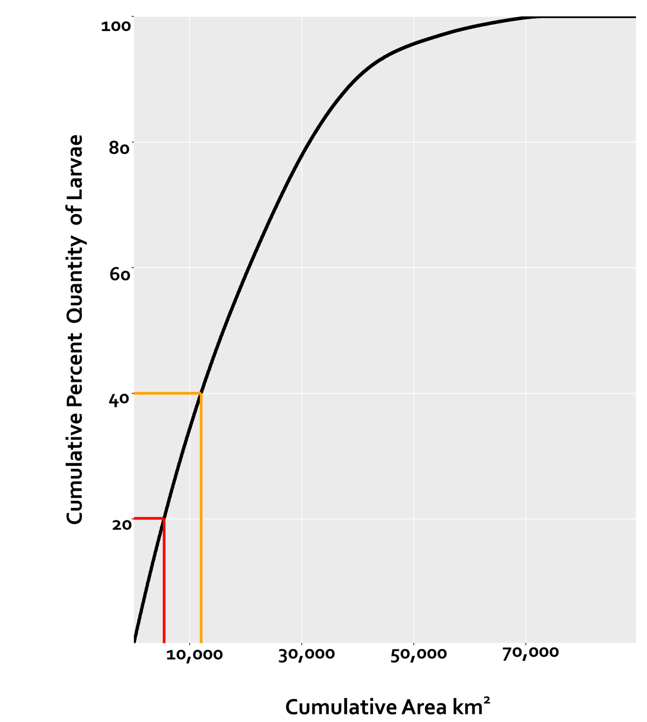

Figure 5. Area Curve that demonstrates the amount of area needed to capture a target percentage of larvae, based on results from 2009-2015 for all four species.

Our results allow managers to determine how much area must be protected from fishing in order to achieve specific larval conservation goals. With a full understanding of Sanctuary needs and pressures, Sanctuary managers can use these tools to aid in their decision process. Based on our results, Sanctuary managers should consider a small expansion of the Sanctuary and/or creating an additional marine protected area to the South of Gray's Reef.

V MOVING FORWARD

Alternative sites with similar conservation benefits may have different socioeconomic and political costs. Weighing the costs of protecting places with similar benefits will be an important next step.

Forecasts of larval connectivity may help other Sanctuaries better understand which other regional sites warrant protection to achieve key conservation goals.

ACKNOWLEDGEMENTS

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FURTHER INFORMATION AND REFERENCES

More information on the project can be found at our website: **http://grays-reef.weebly.com**

You can also contact us directly at **graysreef@lists.bren.ucsb.edu**

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