



Ecosystem Status Report for the U.S. Caribbean



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Science Center
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Table of contents

1. Executive Summary	1
2. Introduction	2
2.1. About this report	2
2.2. Report structure	2
2.2 Notes on interpreting time series figures	3
3. Fishery management plan objectives and conceptual models	5
5. Tracking performance toward fishery management objectives	11
5.1 Food production	11
Fishery independent surveys of economically important species	11
Commercial landings	13
Pelagic:demersal ratio	13
Maximum length and size structure	13
Changes in target species / landing composition	13
5.2 Socioeconomic health	14
Total, lobster and conch revenues	14
Total, lobster and conch trips	16
Ocean economy employment and wages	16
GDP	16
Unemployment	16
5.3 Equity	17
Gini coefficient for distribution of landings and revenue	17
Commercial fishing community engagement and reliance	17
5.4 Engagement and participation	17
Recreational fishing engagement and participation	17
Commercial fishing engagement and participation	18
5.5 Bycatch reduction	18
Changes in gear type	18

Table of contents

5.5 Governance	21
Number of seasonal closures implemented	21
Number of education and outreach events	22
Number of enforcement actions	22
5.6 Protection of ecosystems	22
Percent coral cover	22
Coral species diversity	22
4. Risks to meeting fishery management objectives	24
Degree heating weeks	24
Ocean acidification via aragonite saturation state	25
Hurricane activity	26
Turbidity	27
Sea surface temperature	27
Marine debris	27
Identified point source pollution sites	29
Primary productivity via ocean color	29
Coastal development via land cover	32
Number of major earthquakes	33
Fishery/market disturbance indicator (maybe belongs in socioeconomic health)	33
Sargassum inundation	33
Tourism via hotel occupancy	34
Population change	34
6. Integrated ecosystem perspectives	35
7. Research Recommendations	36
Data gaps	36
8. Acknowledgements	37
9. Contributors	38
9. References	39
10. Data source table	40

List of Figures

1	Process for selecting indicators for the U.S. Caribbean Ecosystem Status Report	3
2	Example time series plot, showing an indicator plotted with its mean and standard deviation, and trend analysis for the most recent five years of data. See text for more detailed description of specific calculations.	4

List of Tables

1. Executive Summary

Here is where we will paste the executive summary

2. Introduction

2.1. About this report

This report is for the Caribbean Fishery Management Council (CFMC). The purpose of this report is to synthesize ecosystem and socioeconomic information to help the CFMC better meet fishery management objectives. This report relied on both previously identified proposed indicators as well as expert vetting to select a suite of indicators that best address the fishery management plan (FMP) objectives for the U.S. Caribbean. Information in this report is organized into two sections: tracking performance toward fishery management objectives and potential risks to meeting fishery management objectives. The style of this report is based on the 2023 State of the Ecosystem Reports for the Northeast U.S. Shelf.

2.2. Report structure

The CFMC's Science and Statistical Committee, as well as the region's Ecosystem-Based Fishery Management Technical Advisory Panel (EBFM TAP), recently completed a series of conceptual models linking key components of the ecosystem and human activities related to fishing. This report used these conceptual models as a starting list of proposed indicators and matched the indicators to answer FMP objectives when possible. For those objectives that did not have an immediate conceptual model-identified indicator, this report used a decision matrix process for expert vetting (Figure 1).

This decision matrix was composed of a list of proposed indicators compiled from the conceptual models as well as proposed indicators provided via expert input. These potential indicators were vetted and edited by expert small working groups, who then scored a decision matrix (Figure 2) of potential indicators against the following decision criteria: long term data availability, measurability, sensitivity to environmental changes, specificity, spatial and temporal scalability, relevance to specific FMP objectives, and responsiveness to management actions.

Process for Caribbean ESR

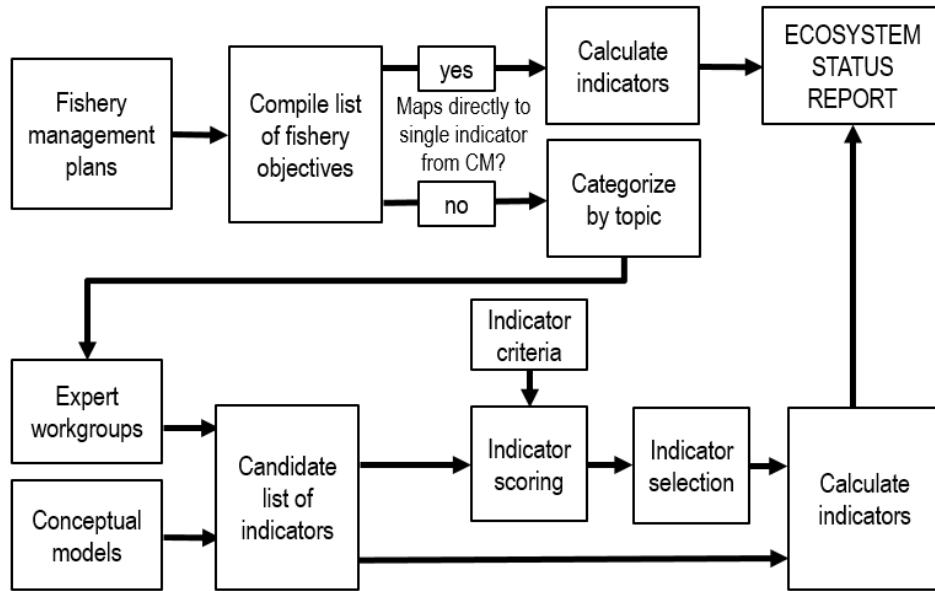


Figure 1: Process for selecting indicators for the U.S. Caribbean Ecosystem Status Report

2.2 Notes on interpreting time series figures

Time series data are plotted in a standardized format for ease of interpretation (e.g., Figure 2). The x-axis represents the temporal dimension, which may be monthly, yearly, or irregular time steps, and the y-axis represents the indicator value in units specified in the axis label. The dashed horizontal line represents the mean indicator value across the entire time series, and the solid horizontal lines denote the mean plus or minus one standard deviation. Red shaded areas and green shaded areas show years for which the indicator value is below or above one standard deviation from the mean, respectively. The blue vertical shaded box highlights the last five years of indicator values, over which additional metrics are calculated. Black circles to the right of each figure indicate whether the indicator values over the last five years are greater (plus sign), less than (minus sign), or within (solid circle) one standard deviation from the mean of the overall time series. Arrows to the right of each figure indicate whether the least squares linear fit through the last five years of data produces a positive or negative slope that is greater than one standard deviation (upward or downward arrows respectively), or less than one standard deviation (left-right arrow).

2. Introduction

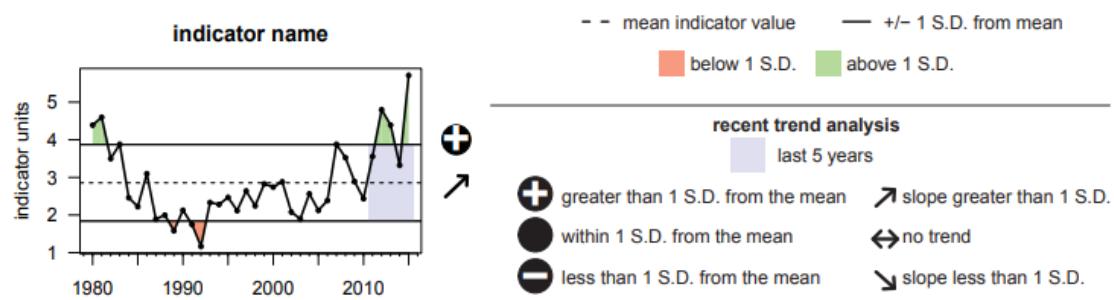


Figure 2: Example time series plot, showing an indicator plotted with its mean and standard deviation, and trend analysis for the most recent five years of data. See text for more detailed description of specific calculations.

3. Fishery management plan objectives and conceptual models

This report's indicator selection process sought to select indicators that corresponded to the island based fishery management plan (FMP) objectives in order to track performance, and also selected indicators related to risks to meeting these management objectives. The following figure shows indicators selected per FMP objective. Indicators were also sourced and considered from the conceptual model exercise completed by the Council's Science and Statistical Committee and District Advisory panels, which began in 2019. Top scored connections in ecosystem components were considered in the ESR indicator suite as well (Rivera et al, in publication).

3. Fishery management plan objectives and conceptual models

FMP Objective	Col2	Col3	Col4	Col5	Col6
Objective 1: Provide for long-term sustainable use of fisheries resources within the limits of local ecosystem production using a precautionary, ecosystem-based approach to management that accounts for uncertainty and relevant biological, ecological, economic, and social factors in the fishery, including the benefits of food production, recreational opportunities, and protection of marine ecosystems . Prevent overfishing, rebuild overfished stocks, and achieve OY on a continuing basis.	Total commercial landings, lobster landings, conch landings	Sustainability of economically important reef fish-FID from RVC on mutton, yellowtail, red hind, and queen triggerfish			
Objective 2: Reduce bycatch and waste in the fishery.					
Objective 3: Ensure the metrics upon which OY is based are derived from the best available scientific information and are updated continuously every five years to respond to changing ecological, biological, economic, and social conditions.					
Objective 4: Promote international and domestic cooperation in the management of pan-Caribbean stocks.					

3. Fishery management plan objectives and conceptual models

FMP Objective	Col2	Col3	Col4	Col5	Col6
Objective 5: Minimize conflicts between stakeholders by promoting effective marine spatial planning					
Objective 6: Promote fair and equitable use of fishery resources , recognizing the importance of those resources to fishing communities within the context of differences in local environment, culture, markets, user groups, gears, and seafood preferences.					
Objective 7: Establish resource access permits as necessary and appropriate to facilitate data collection, sustainability, and long-term yield.					
Objective 8: Provide flexibility in the management process which minimizes regulatory delay and allows for rapid adaptation to changing resource abundance, availability, health, or preference , using the best available scientific and socio-economic information.					

3. Fishery management plan objectives and conceptual models

FMP Objective	Col2	Col3	Col4	Col5	Col6
Objective 9: Devise a regulatory framework that maximizes the efficiency and efficacy of enforcement efforts within and across jurisdictional boundaries while promoting the safe conduct of fishing operations.					
Objective 10: Promote awareness of laws and regulations governing marine resource management and the science and social obligations that support that management, and to ensure informed public input into the management process.					
Objective 11: Ensure the socioeconomic health of the fishing communities dependent on federal fishery resources.					
Objective 12: Protect spawning aggregations and, when needed, the habitats supporting those aggregations to ensure the future health of the resource.					

3. Fishery management plan objectives and conceptual models

FMP Objective	Col2	Col3	Col4	Col5	Col6
Objective 13: Describe and identify EFH, adverse impacts on EFH, and other actions to conserve and enhance EFH. Adopt management measures that minimize adverse impacts from fishing on EFH and promote habitat conservation, including designation of specific habitat areas of particular concern within EFH for more focused management action.					
Objective 14: Map, define, and manage habitat upon which the resource depends, with particular emphasis on coral reef resources throughout the region.					
Objective 15: Ensure continued provision of ecosystem services derived from living marine resources , including adequate abundance of forage resources to ensure a healthy and diverse trophic web.					
Objective 16: Account for ecological relationships and functional roles of species in the fishery that contribute to a healthy ecosystem, such as grazers, forage fish, habitat-builders, and top predators.					

3. Fishery management plan objectives and conceptual models

FMP Objective	Col2	Col3	Col4	Col5	Col6
Objective 17: Require essential scientific data is gathered and analyzed in advance to guide the development of new fisheries to ensure they are sustainable from the start.					
Objective 18: Promote measures to develop and sustainably manage underutilized marine fishery resources.					

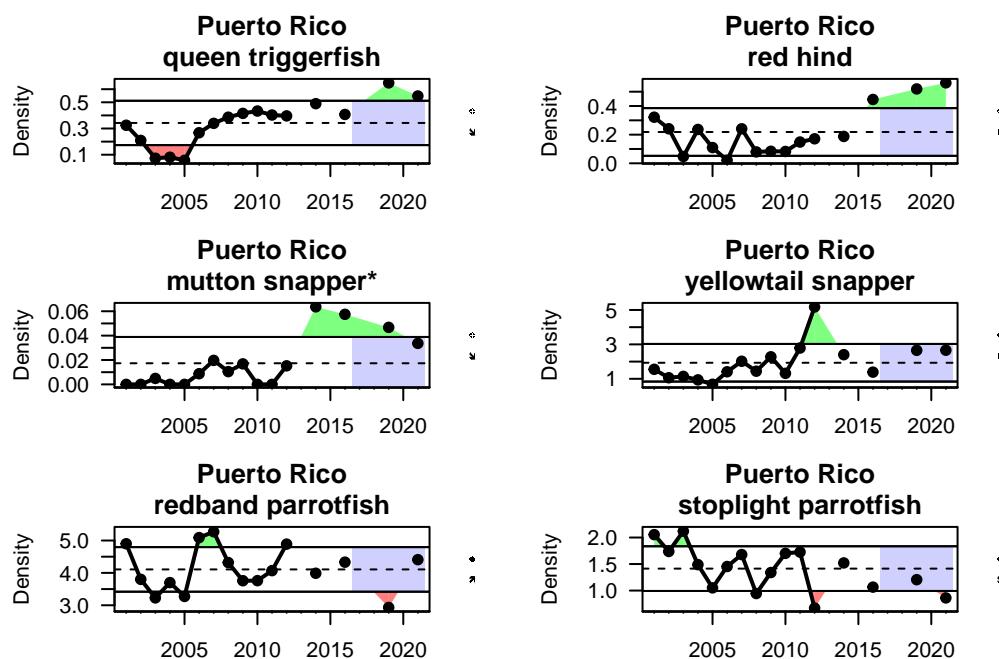
5. Tracking performance toward fishery management objectives

In this section, we examine indicators related to broad, ecosystem-level fishery management objectives.

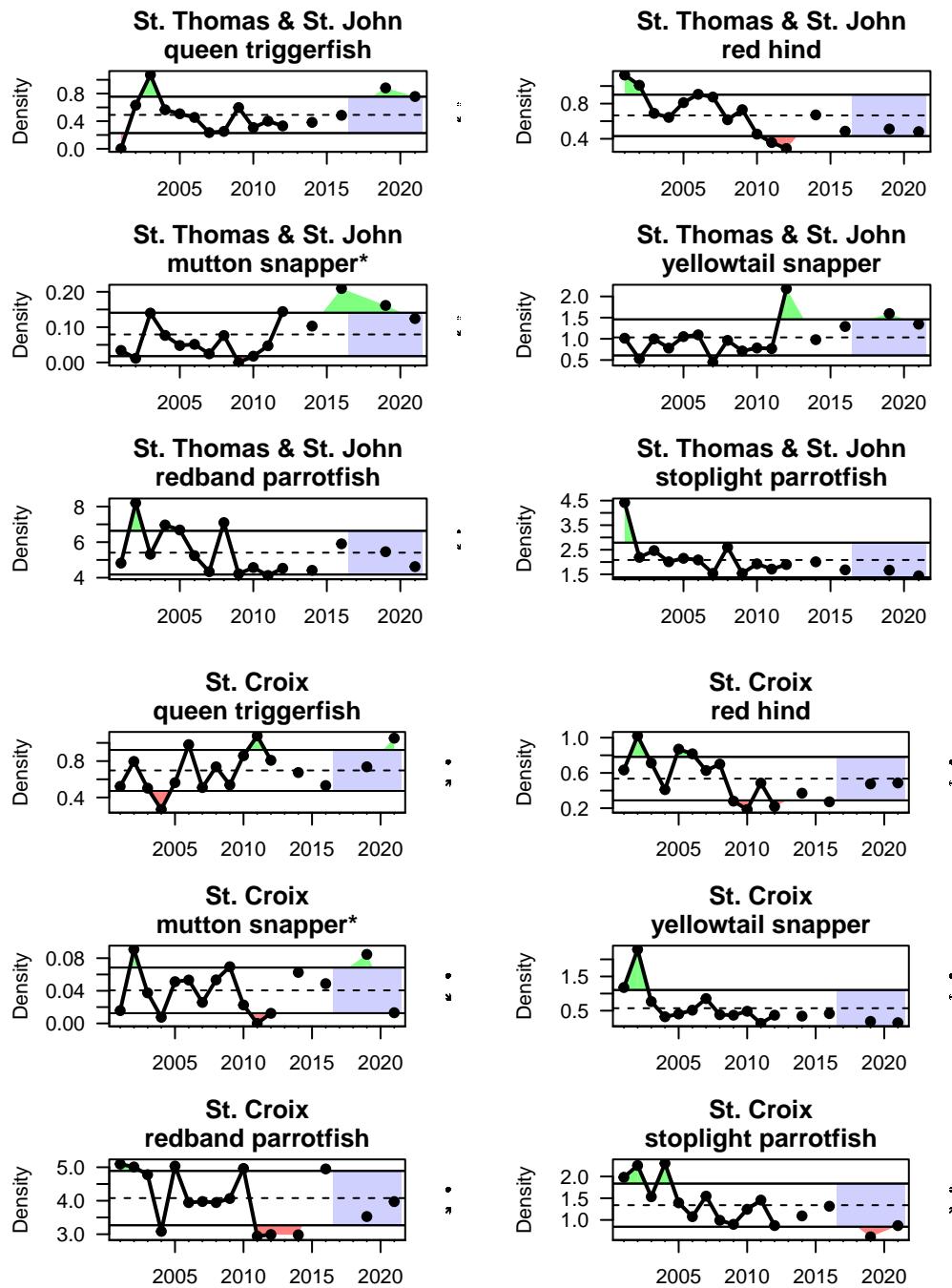
5.1 Food production

Fishery independent surveys of economically important species

Indicator 16 - abundance of economically important fish



5. Tracking performance toward fishery management objectives



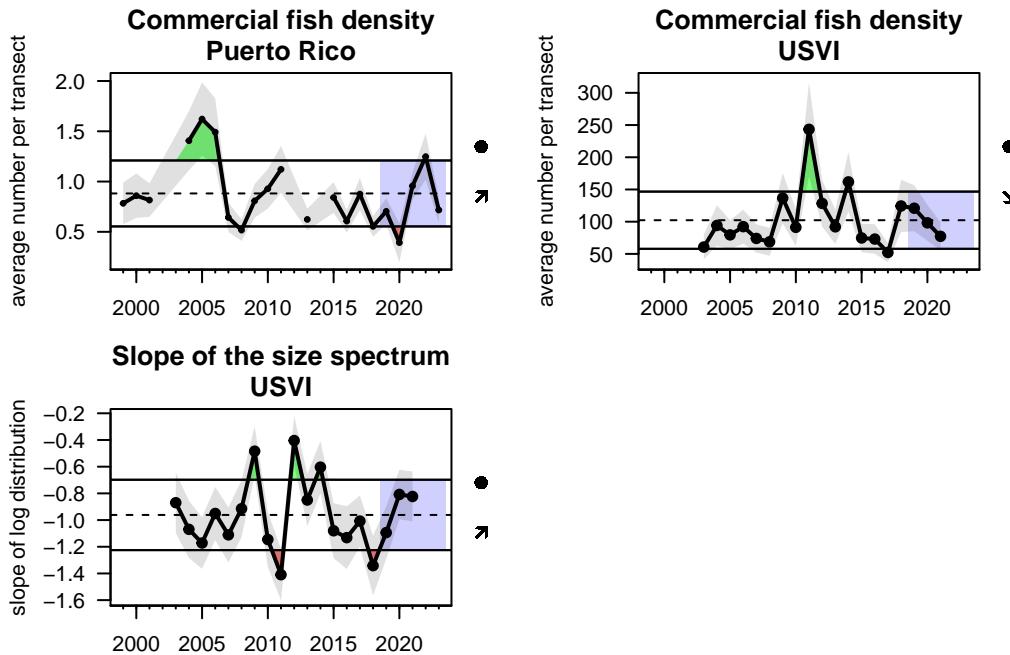
Indicator 16.1 - abundance of commercial fish based on TCRMP and PRCRMP Indicator
 16.2 - slope of the size spectrum based on TCRMP and PRCRMP

5. Tracking performance toward fishery management objectives

Commercial landings

Indicator 17

```
load("../indicator_objects/landings.RData") plotIndicatorTimeSeries(inddata, coltoplot = 1:6, trendAnalysis = T, sublabel = T)
```



Pelagic:demersal ratio

Indicator 18

Maximum length and size structure

Indicator 19 - Lmax indicator

Changes in target species / landing composition

Indicator 20

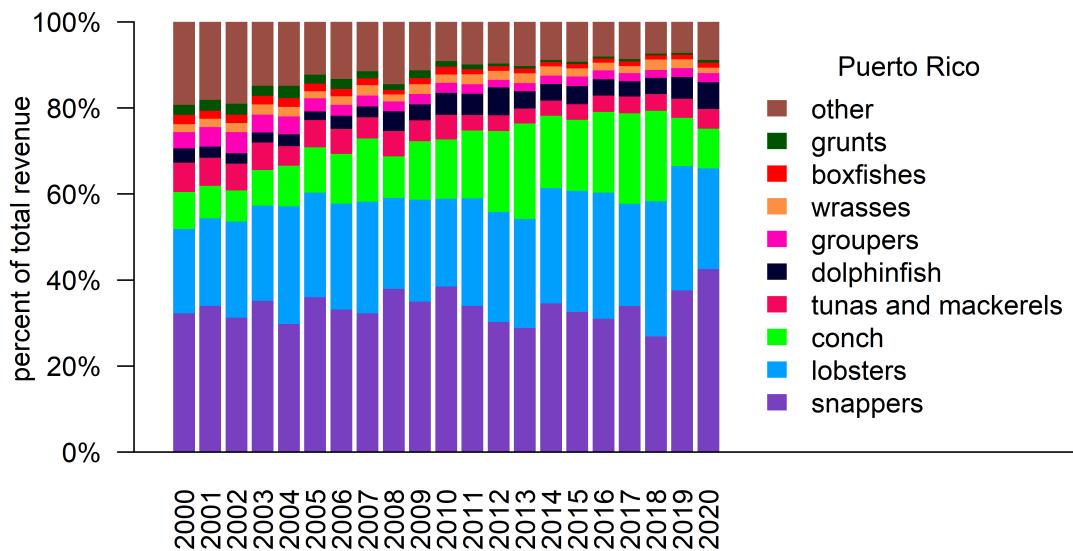
5. Tracking performance toward fishery management objectives

```
load("../indicator_objects/total_landings.RData")      plotIndicatorTimeSeries(inddata,
coltoplot = 1:9, plotrownum = 3, plotcolnum = 3, trendAnalysis = T, #sublabel = T)
```

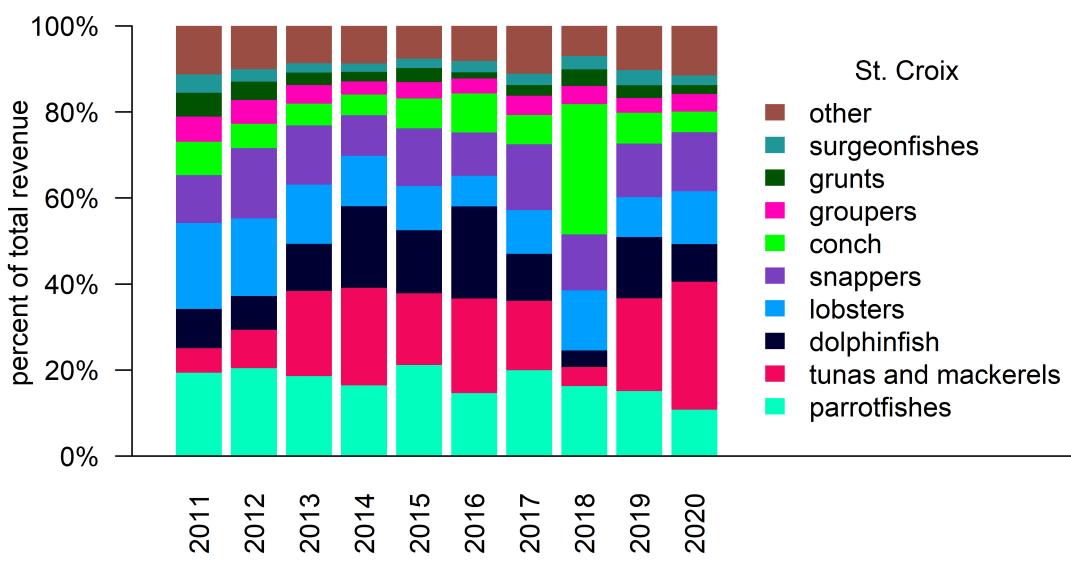
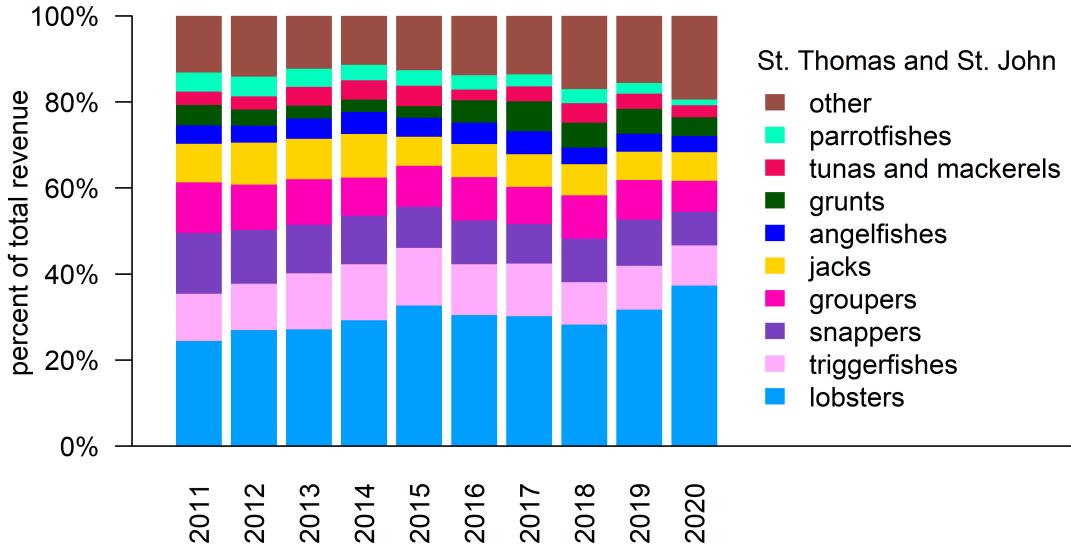
5.2 Socioeconomic health

Total, lobster and conch revenues

Indicator 21 - percent revenues by species group



5. Tracking performance toward fishery management objectives



5. Tracking performance toward fishery management objectives

Total, lobster and conch trips

Indicator 22 - number of trips

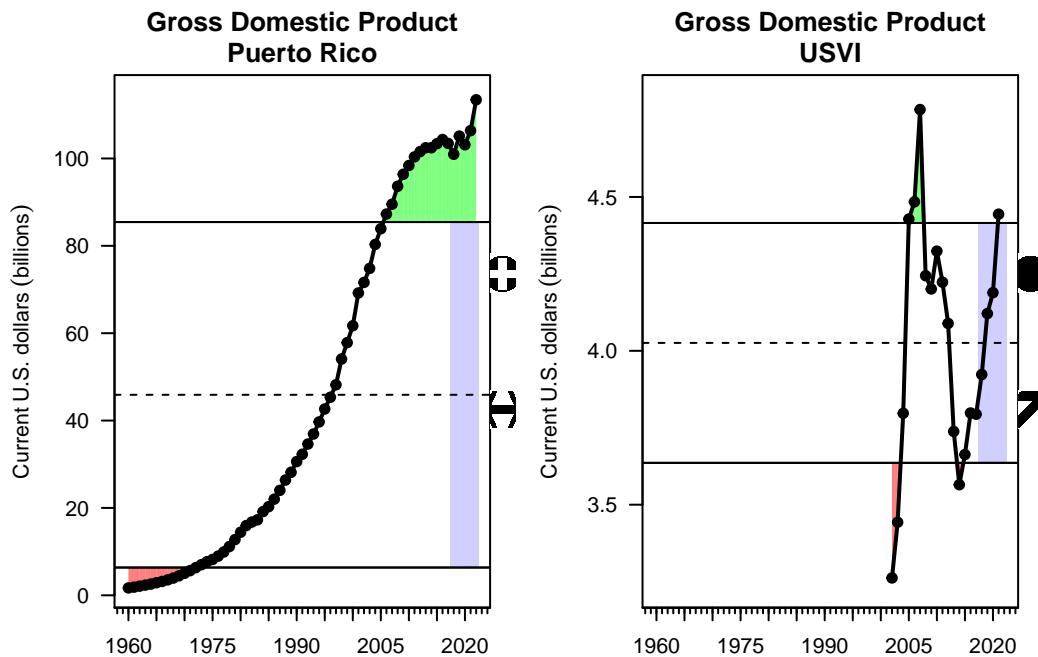
Ocean economy employment and wages

Indicator 23

```
load("../indicator_objects/OceanNAICS.RData") plotIndicatorTimeSeries(inddata, colto-  
plot = 1:8, plotrownum = 2, trendAnalysis = T, sublabel = T)
```

GDP

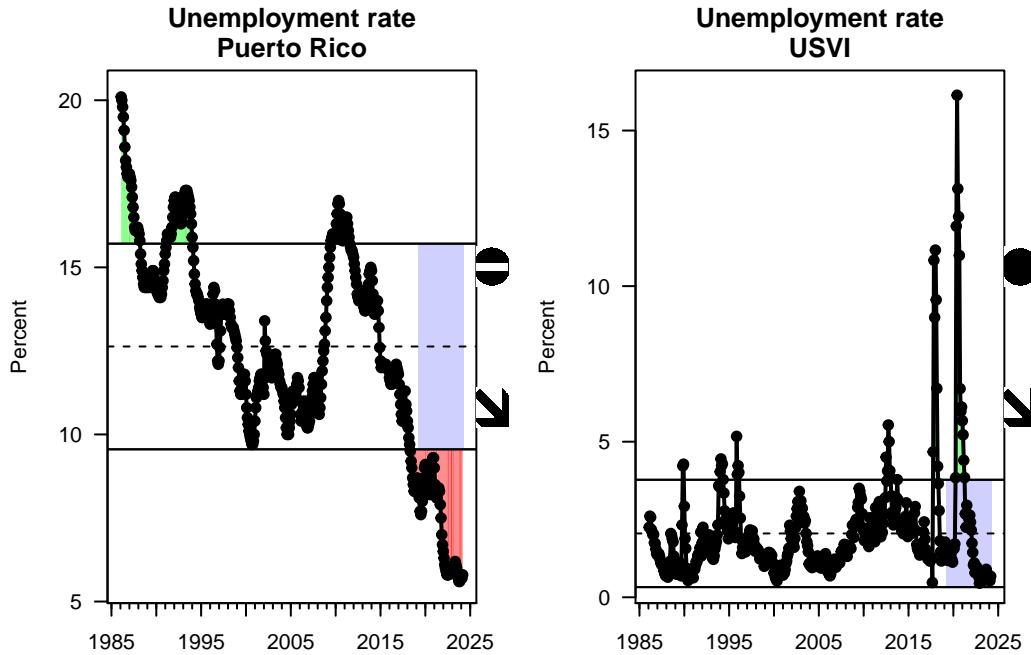
Indicator 24



Unemployment

Indicator 25

5. Tracking performance toward fishery management objectives



5.3 Equity

Gini coefficient for distribution of landings and revenue

Indicator 26

```
load("../indicator_objects/gini.RData") plotIndicatorTimeSeries(inddata, coltoplot = 1:3,
plotrownrnum = 2, trendAnalysis = T, sublabel = T)
```

Commercial fishing community engagement and reliance

Indicator 27 - working with Tarsila on

5.4 Engagement and participation

Recreational fishing engagement and participation

Indicator 28

5. Tracking performance toward fishery management objectives

```
load("../indicator_objects/total_rec_catch.RData")      plotIndicatorTimeSeries(inddata,  
coltoplot = 1:2, trendAnalysis = T, sublabel = T)
```

Commercial fishing engagement and participation

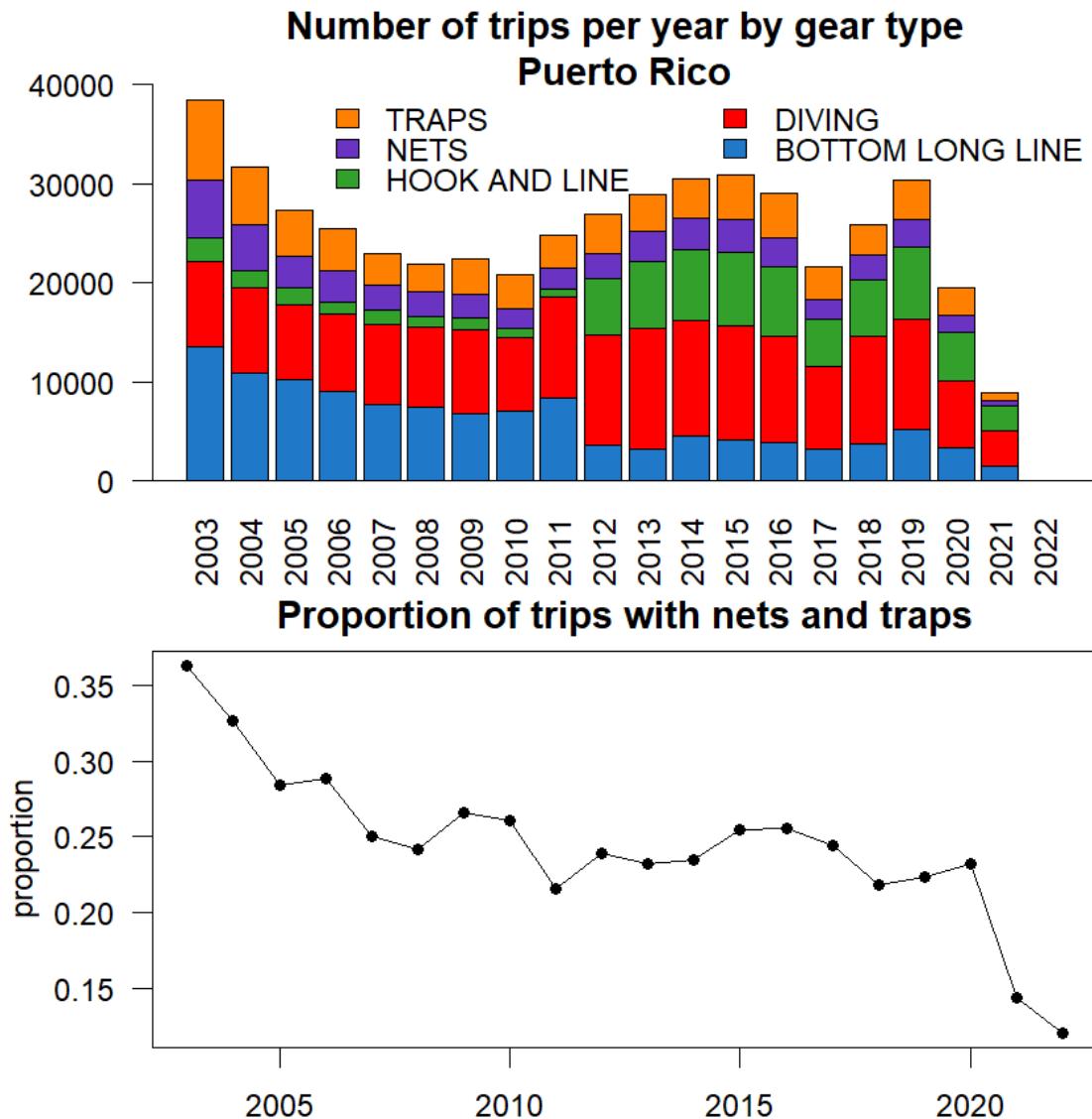
Indicator 29

5.5 Bycatch reduction

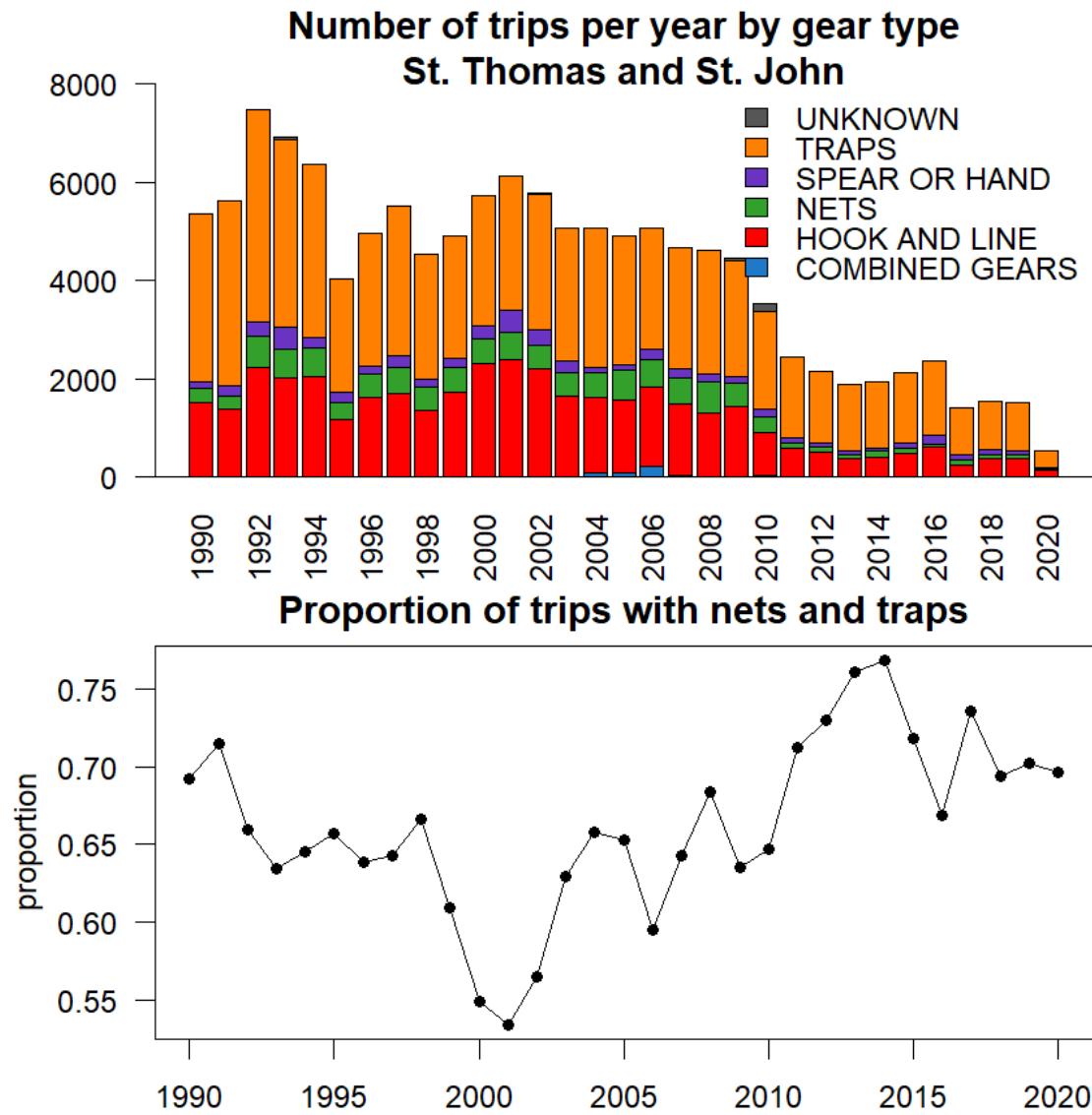
Changes in gear type

Indicator 30

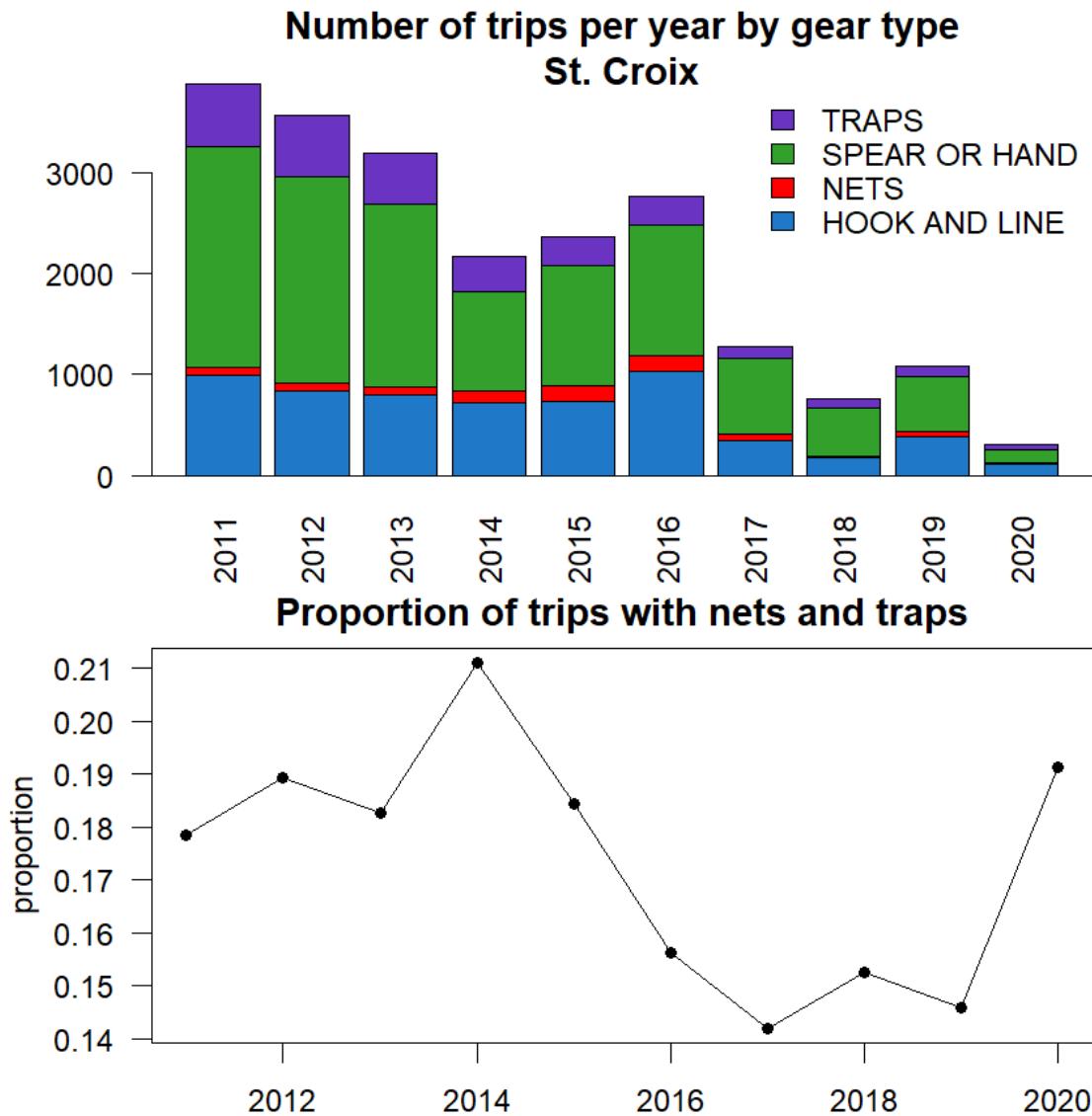
5. Tracking performance toward fishery management objectives



5. Tracking performance toward fishery management objectives



5. Tracking performance toward fishery management objectives



5.5 Governance

Number of seasonal closures implemented

Indicator 31

5. Tracking performance toward fishery management objectives

Number of education and outreach events

Indicator 32

Number of enforcement actions

Indicator 33

5.6 Protection of ecosystems

Percent coral cover

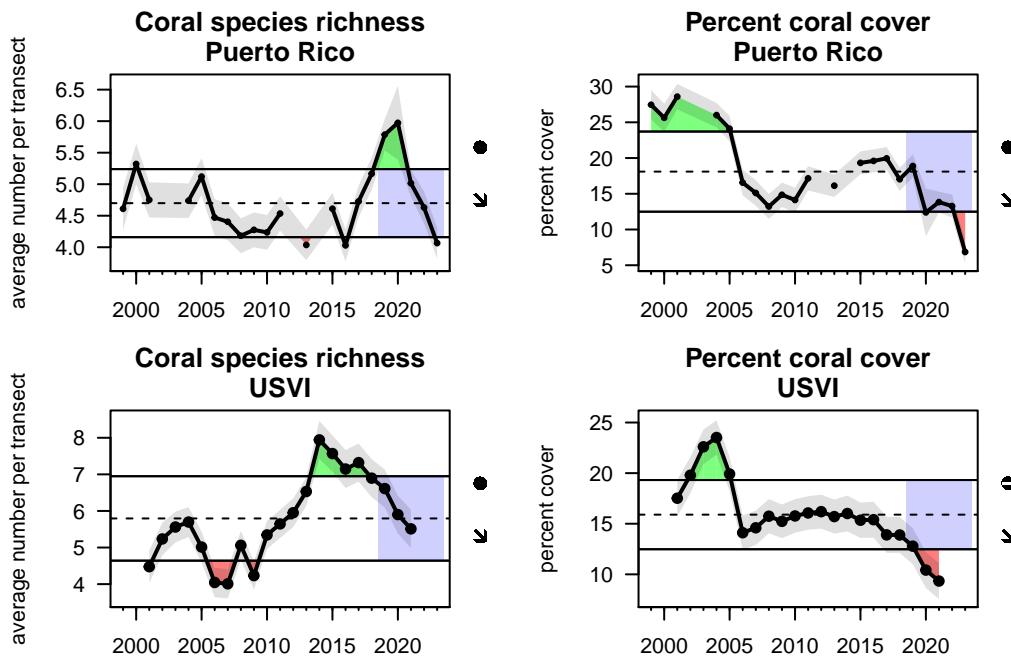
Indicator 34

```
load("../indicator_objects/NCRMP_coral_cover_richness.RData") plotIndicatorTime-  
Series(inddata, coltoplot = 1:6, sublabel = T, trendAnalysis = F)
```

Coral species diversity

Indicator 35

5. Tracking performance toward fishery management objectives

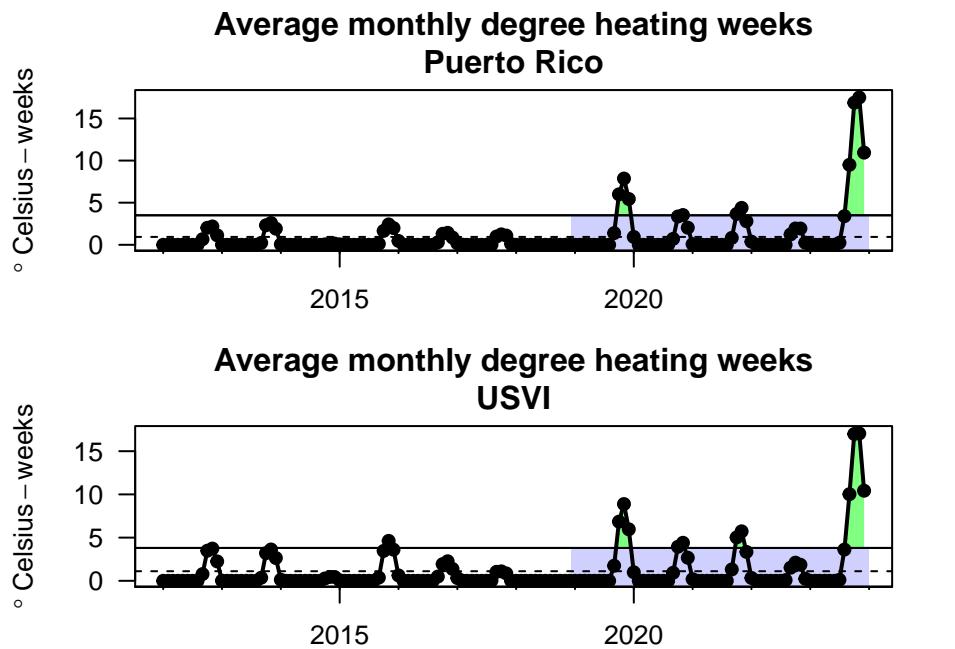


4. Risks to meeting fishery management objectives

Degree heating weeks

The degree heating week (DHW) provides a measure of cumulative temperature anomalies at least 1°C above the maximum monthly mean sea surface temperature over the prior twelve-week period for a given satellite data grid point (5km pixel). Both the intensity and duration of the heat stress impact the DHW, which is measured in units of “degree Celsius-weeks” (or °C-weeks). The DHW data presented below is for the Puerto Rico and U.S. Virgin Islands Daily 5km Regional Virtual Stations. The Regional Virtual Stations provide a time series of DHW data that is representative of the whole region’s thermal conditions. Briefly, the reef pixels within a region are identified based on the most updated maps of coral reef locations, and a 20 km buffer around these reef areas is added as a boundary for the virtual station. The DHW value for the virtual station is based on the 90th percentile Coral Bleaching Hotspot value (i.e., the number of degrees Celsius above the maximum monthly mean sea surface temperature). Field observations of coral bleaching have indicated that a DHW value of 4°C-weeks can lead to significant coral bleaching, while a DHW value of 8°C-weeks or above can likely lead to severe, widespread bleaching and substantial mortality. The monthly mean DHW value is plotted below for the Puerto Rico and Virgin Island virtual stations. An increasing trend was seen for both Puerto Rico and the U.S. Virgin Islands in the last five years. Peak number of degree heating weeks with value more than one standard deviation above the mean were seen in late 2005, late 2006, late 2010, and late 2019, reflecting times of most pressure on coral reef resources. Indeed, mass bleaching events were experienced in the U.S. Caribbean region in 2005, 2010 and 2019 (see observed coral bleaching indicator). More information on NOAA Coral Reef Watch’s Methodology can be found at: <https://coralreefwatch.noaa.gov/product/5km/methodology.php#dhw> Text files of DHW data were downloaded at: (Accessed August 16, 2021) <https://coralreefwatch.noaa.gov/product/vs/data.php>.

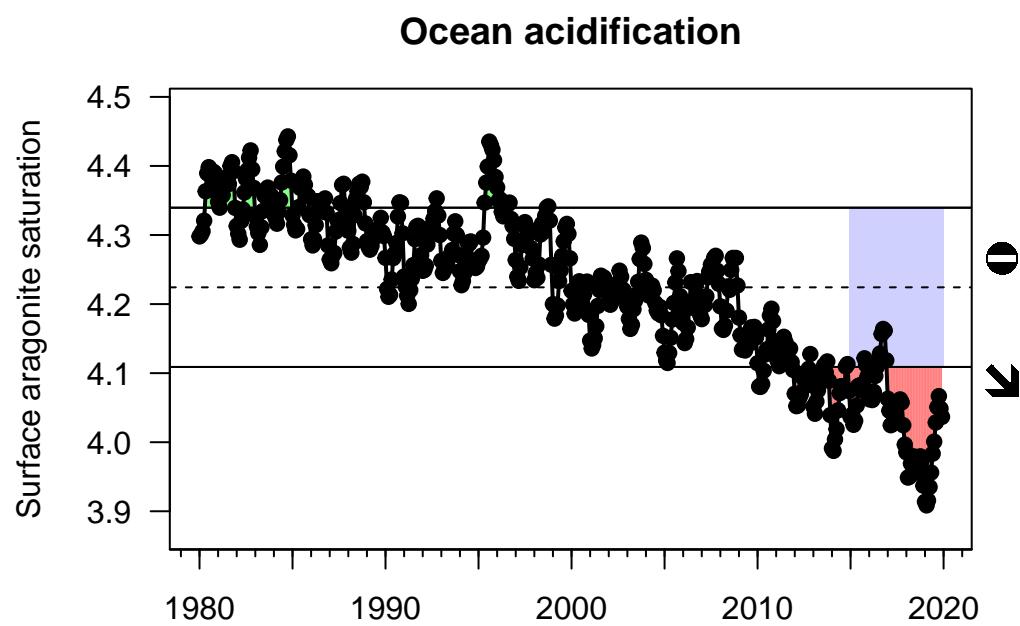
4. Risks to meeting fishery management objectives



Ocean acidification via aragonite saturation state

Indicator 2

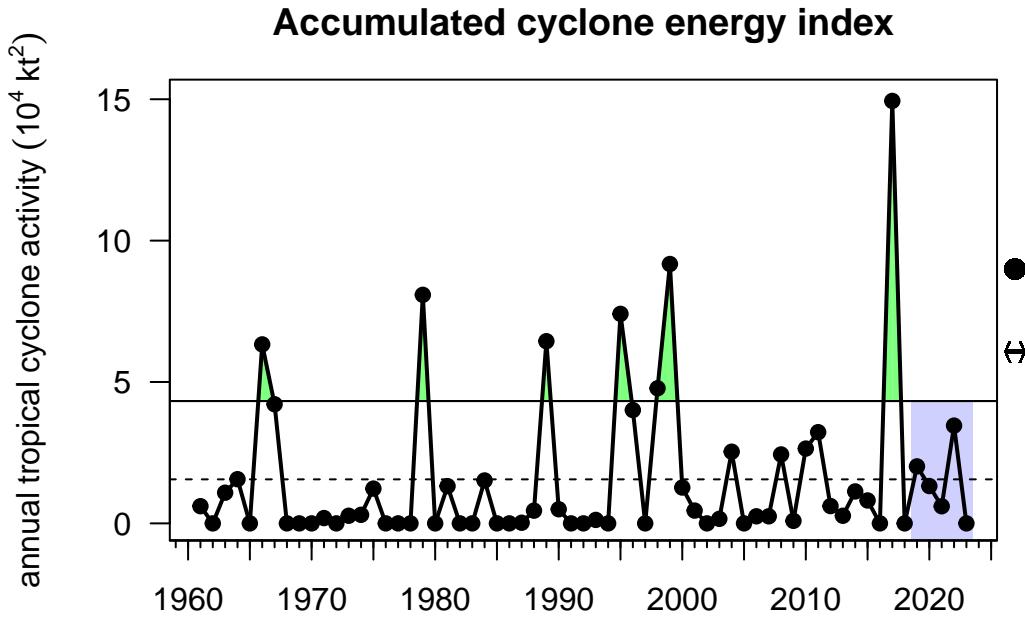
4. Risks to meeting fishery management objectives



Hurricane activity

Indicator 3

4. Risks to meeting fishery management objectives



Turbidity

Indicator 4

```
load("../indicator_objects/turbidity.RData") plotIndicatorTimeSeries(ind, coltoplot = 1:3,
plotrownrnum = 2, trendAnalysis = T, #dateformat = "%m-%Y", sublabel = T)
```

Sea surface temperature

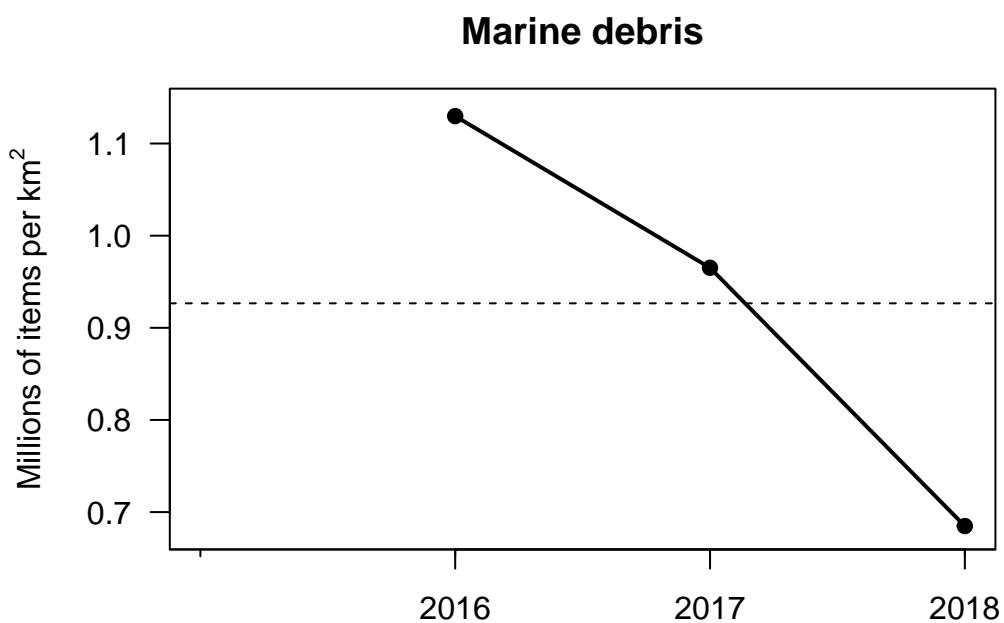
Indicator 5

```
load("../indicator_objects/Carib_SST.RData") plotIndicatorTimeSeries(ind, coltoplot = 1:3,
trendAnalysis = T, sublabel = T, #dateformat = "%m-%Y")
```

Marine debris

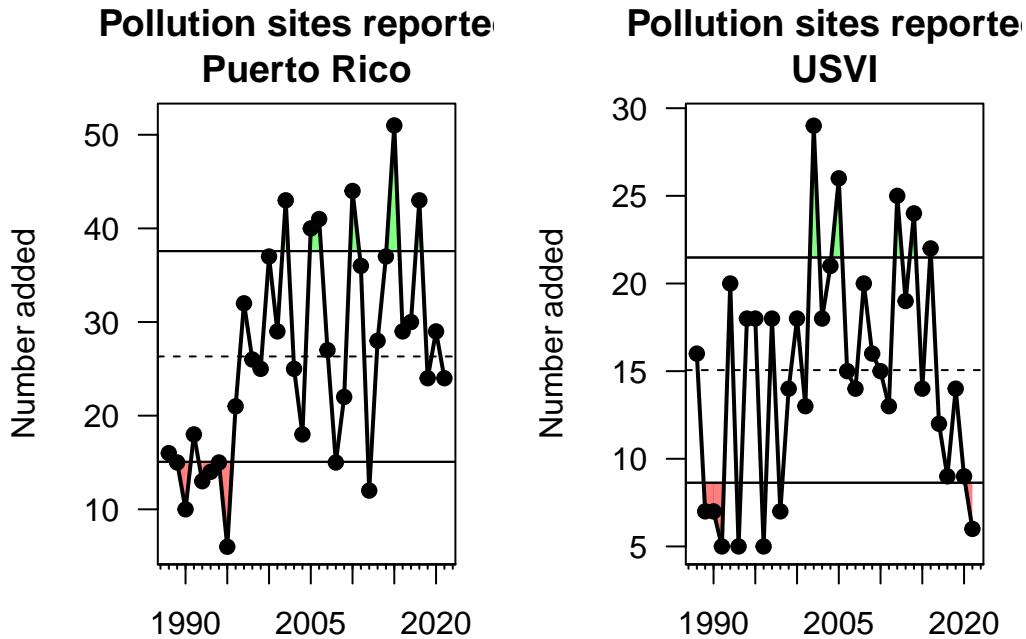
Indicator 6

4. Risks to meeting fishery management objectives



4. Risks to meeting fishery management objectives

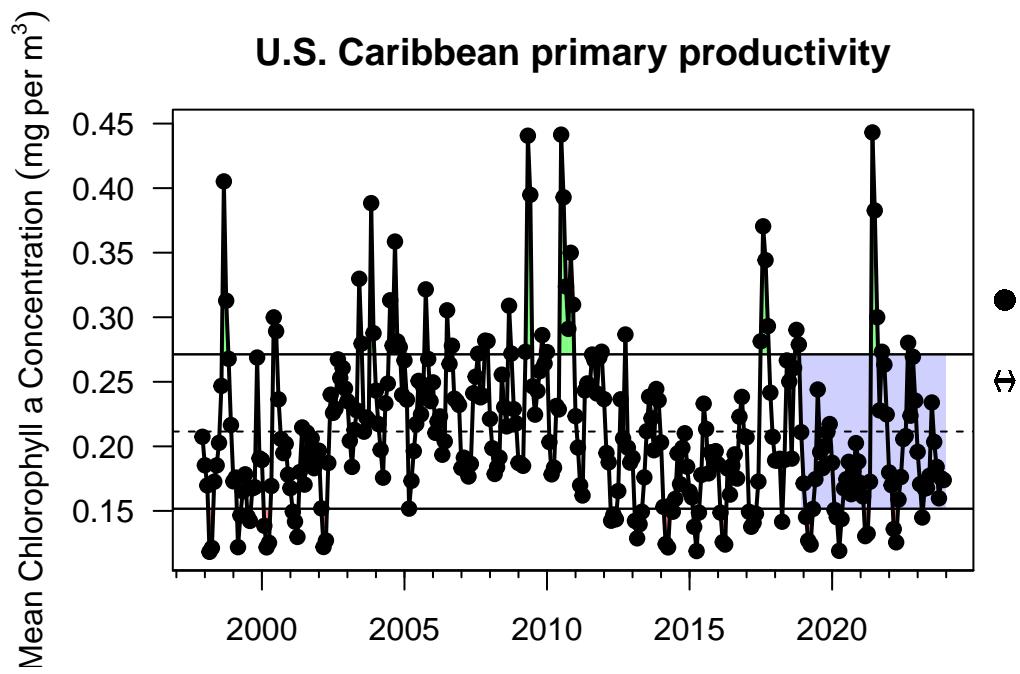
Identified point source pollution sites



Primary productivity via ocean color

Indicator 8

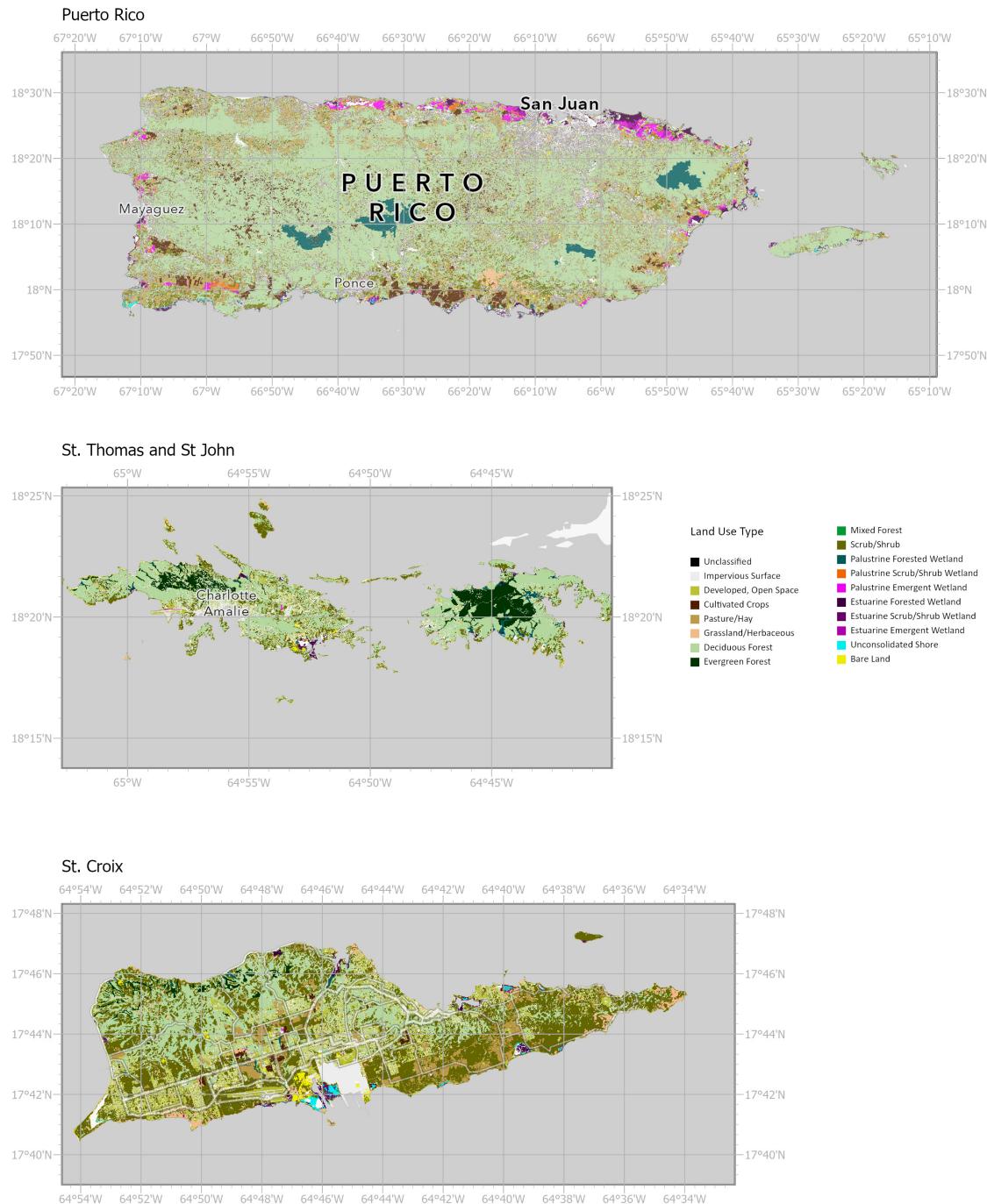
4. Risks to meeting fishery management objectives



4. Risks to meeting fishery management objectives

4. Risks to meeting fishery management objectives

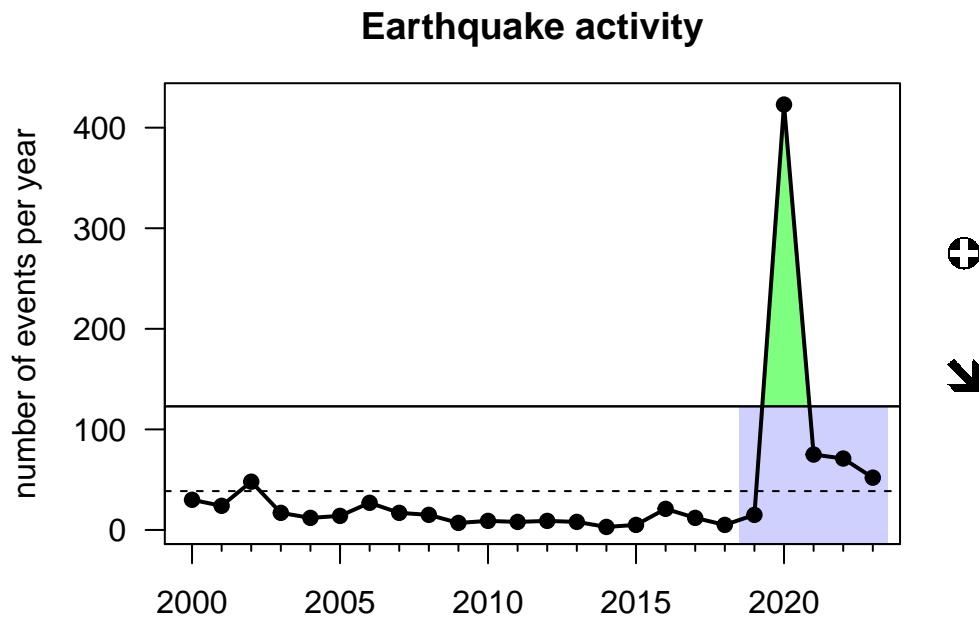
Coastal development via land cover



4. Risks to meeting fishery management objectives

Number of major earthquakes

Indicator 10



Fishery/market disturbance indicator (maybe belongs in socioeconomic health)

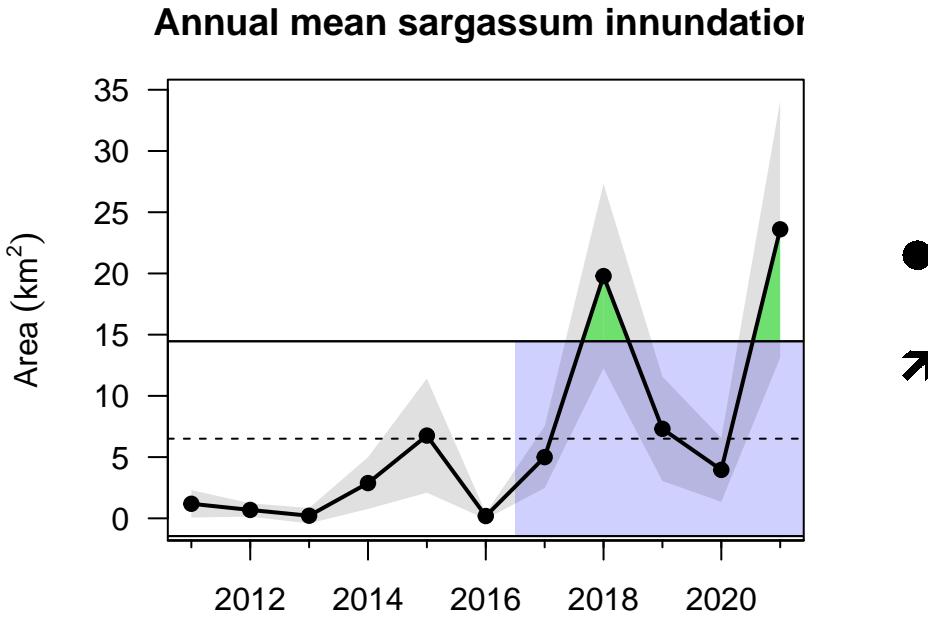
Indicator 11

```
load("../indicator_objects/disturbance.RData") plotIndicatorTimeSeries(inddata, colto-  
plot = 1:3, trendAnalysis = T, sublabel = T)
```

Sargassum inundation

Indicator 12

4. Risks to meeting fishery management objectives



```
load("../indicator_objects/sargassum_innundation_monthly_mean_hu.RData") plotIndicatorTimeSeries(inddata, coltoplot = 1:3, sublabel = T, trendAnalysis = T, #dateformat = "%Y%b")
```

Tourism via hotel occupancy

Indicator 13

```
load("../indicator_objects/hotel_occupancy_rates_USVI_and_PR.RData") plotIndicatorTimeSeries(inddata, coltoplot = 1:2, sublabel = T, trendAnalysis = T, #dateformat = "%Y%b")
```

```
load("../indicator_objects/hotel_occupancy.RData") plotIndicatorTimeSeries(inddata, coltoplot = 1:2, sublabel = T, trendAnalysis = T, #dateformat = "%Y%b")
```

Population change

Indicator 15 - MAPS but also should be census data

6. Integrated ecosystem perspectives

Stoplight plot (maybe this should be in the beginning material)

7. Research Recommendations

Data gaps

8. Acknowledgements

9. Contributors

Editors Mandy Karnauskas, Carissa Gervasi

Contributors Kelly Montenero, Seann Regan, Amy Freitag, Andrea Chan, Chuanmin Hu, Erica K. Towle, Laura Jay Grove, Jeremiah Blondeau, Sarah Groves, Shay Viehman, Nicole Besemer, Juan Agar, Kevin McCarthy, Manoj Shivlani, Mike Jepson, Adyan Rios, Matt McPherson, Miguel Figuerola, Nicole Angeli, Sennai Habtes, Dione Swanson, Liajay Rivera

9. References

10. Data source table