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# Florida Keys Integrated Ecosystem Assessment Ecosystem Status Report

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Miami, Florida

September 2020

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## Disclaimer

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# Florida Keys Integrated Ecosystem Assessment Ecosystem Status Report

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September 2020

**UNITED STATES DEPARTMENT OF COMMERCE**
Mr. Wilbur L. Ross, Jr., Secretary

**NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION**
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National Oceanic and Atmospheric Administration
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# Florida Keys Integrated Ecosystem Assessment Ecosystem Status Report

September 2020

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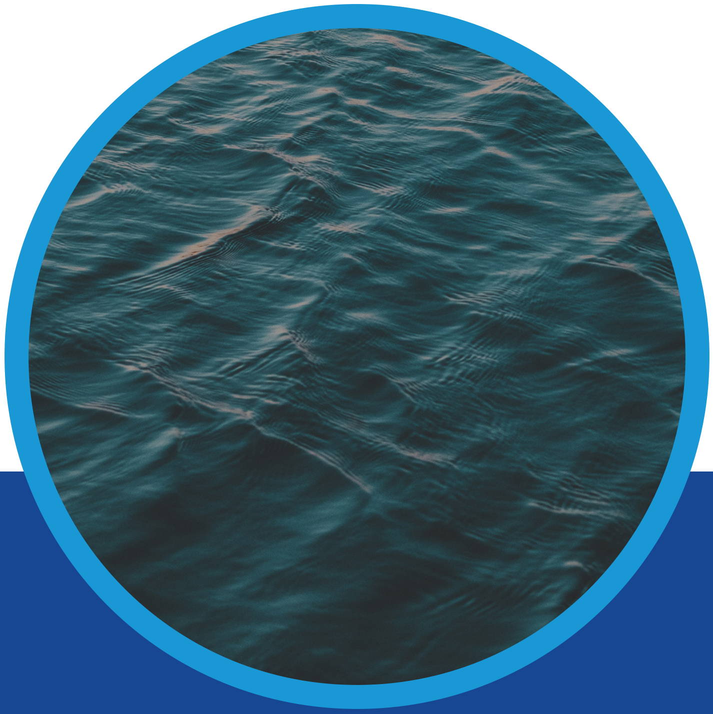

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# Table of Contents

# Report Objective

***Develop socioecological indicators in the Florida Keys National Marine Sanctuary (FKNMS) and assess their status and trends. These indicators will be related to the 17 questions in the condition report. Establish the baseline condition and trends in key indicators prior to the implementation on a new FKNMS management plan.***

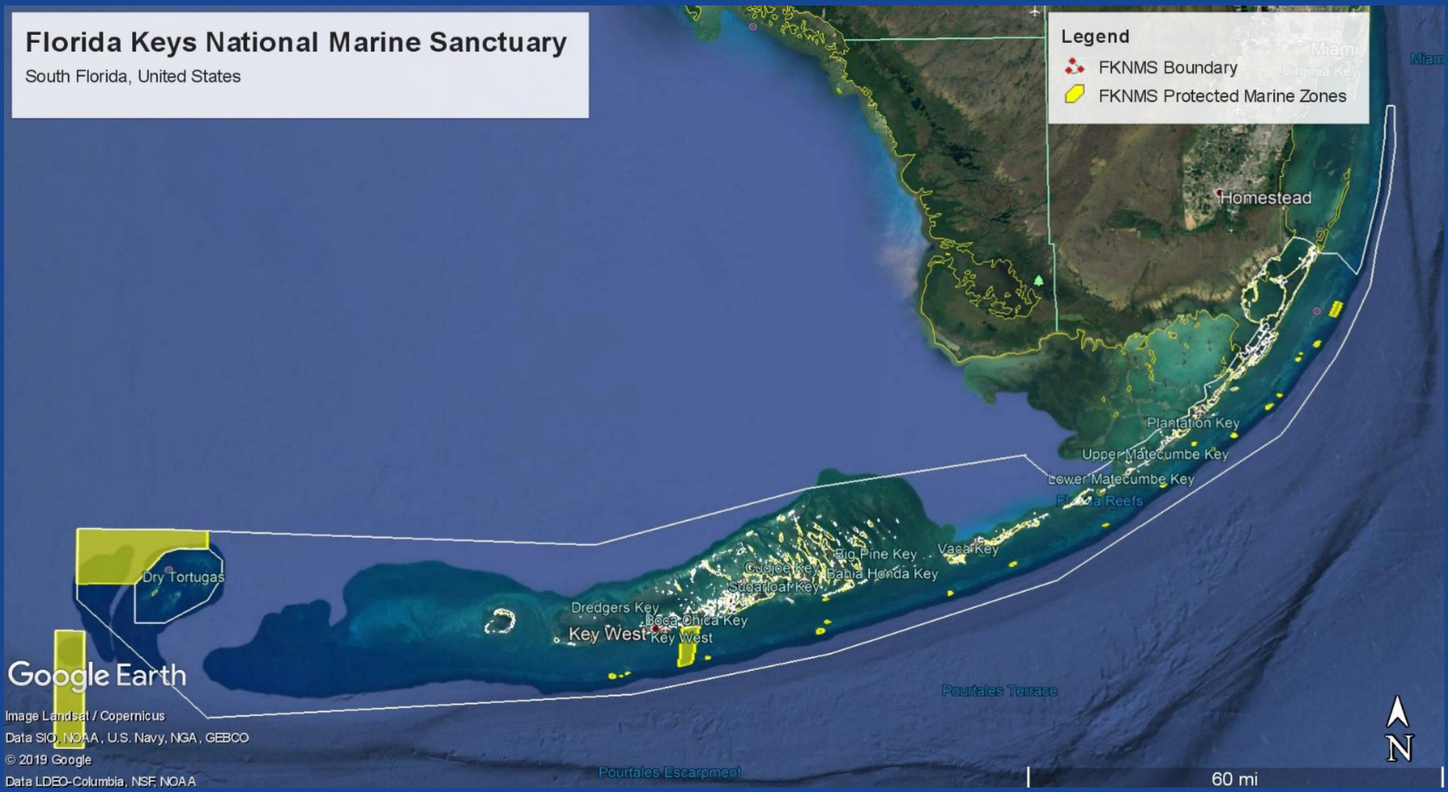



**Figure 1.** **Florida Keys National Marine Sanctuary study area. Image: Google Earth**

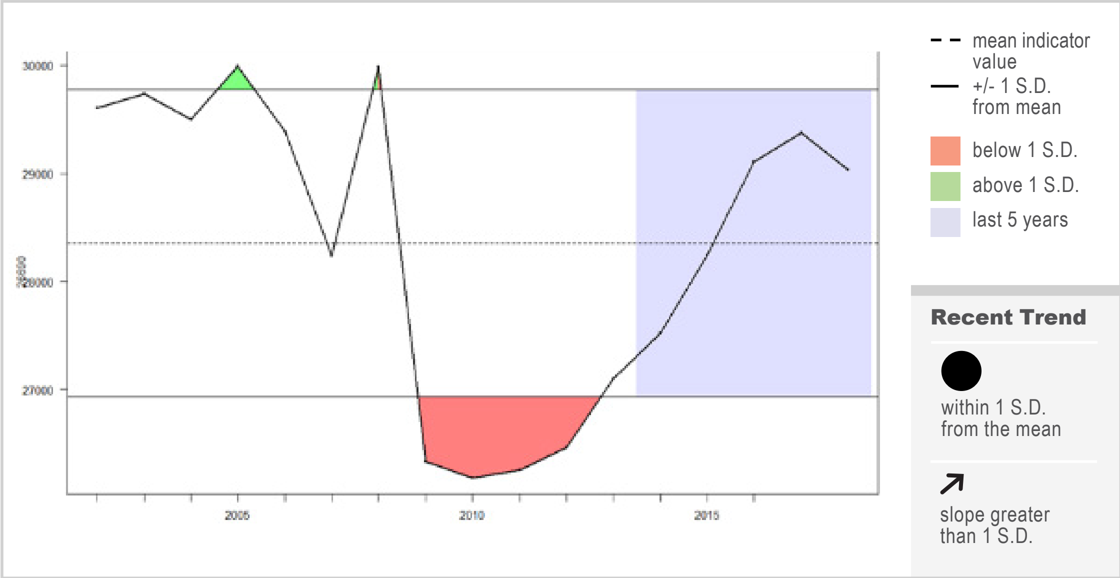
# Executive Summary

The Gulf of Mexico NOAA Integrated Ecosystem Assessment Program seeks to provide scientific knowledge of the Florida Keys National Marine Sanctuary integrated ecosystem with the aim of supporting Ecosystem-Based Management, and transfering that knowledge to scientists and managers. The purpose of this report is to provide a broad, interdisciplinary overview of the condition and status of ecosystem and human activity components of the Florida Keys National Marine Sanctuary (FKNMS), with respect to recent and historical trends. In order to understand the status and trends of the condition and current state of FKNMS, a suite of indicators, in accordance with the Sanctuary Condition Report sections and questions, was developed and vetted via qualitative and quantitative processes and is presented in this report. The public time series data available on these indicators were requested and sourced via our team of experts, and status and trend analyses were completed and graphed in order to illustrate long term and recent changes in socioeconomic and ecological conditions of the marine resources in the Florida Keys National Marine Sanctuary.

## Highlights From This Analysis

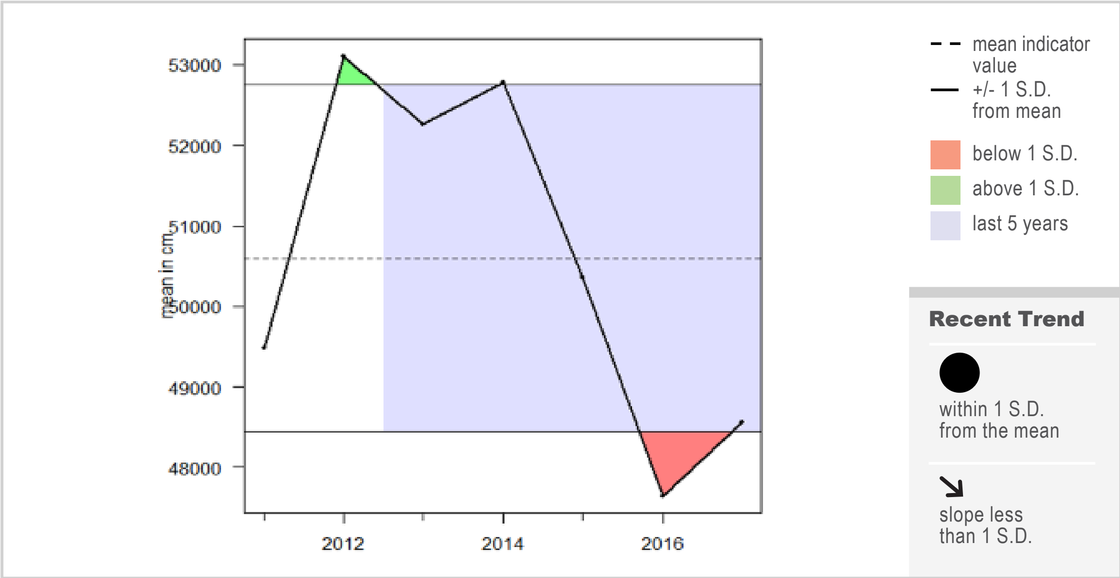
### *Total Number of Registered Vessels*

**A decrease and then increase in total registered vessels as well as total tourism value in Monroe County in response to the 2008 Great Recession**



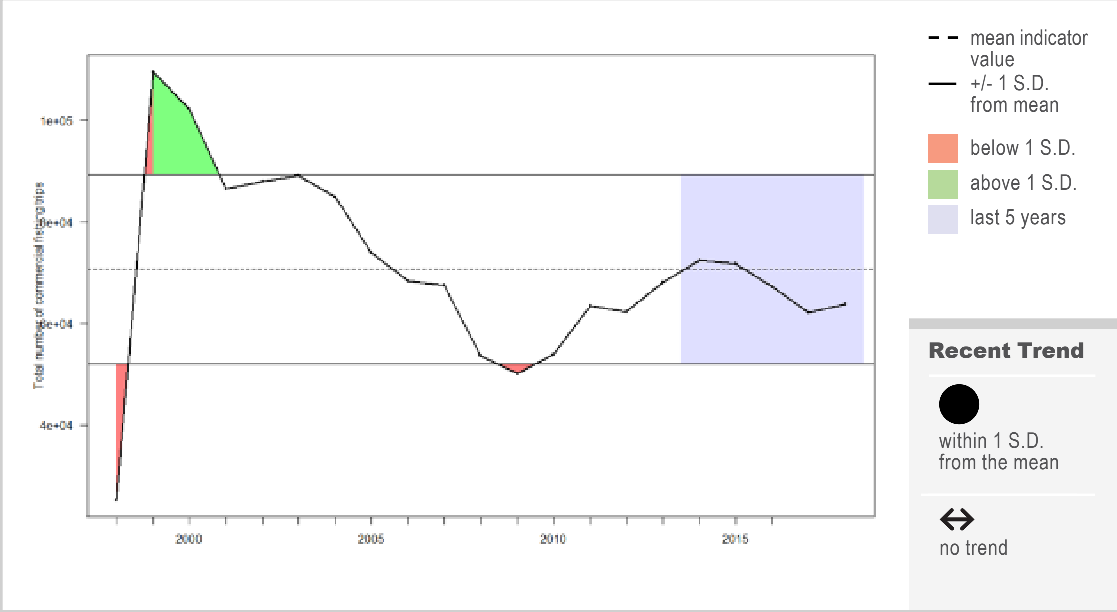

### *Stony Coral Live Tissue Area*

**A decrease in spatial coverage of important habitat building species, including live tissue area of stony corals, volume of barrel sponges, abundance of calcareous green macroalgae and abundance of seagrass in the Florida Keys.**



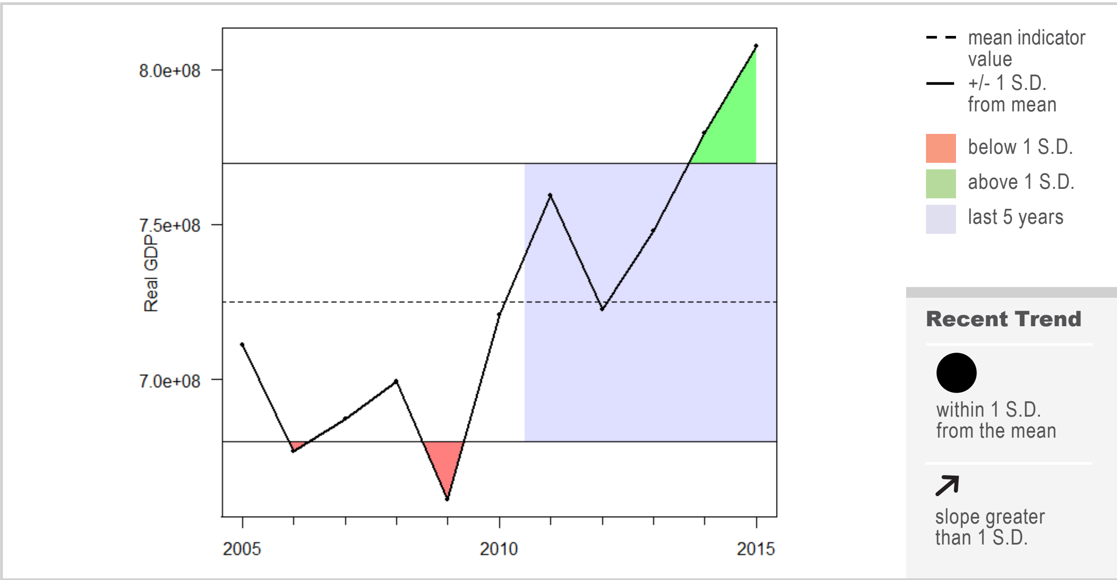
### *Commercial Fishing Activity*

**Stable to decreasing pressure via trends in the number of total and economically important species commercial fishing trips.**



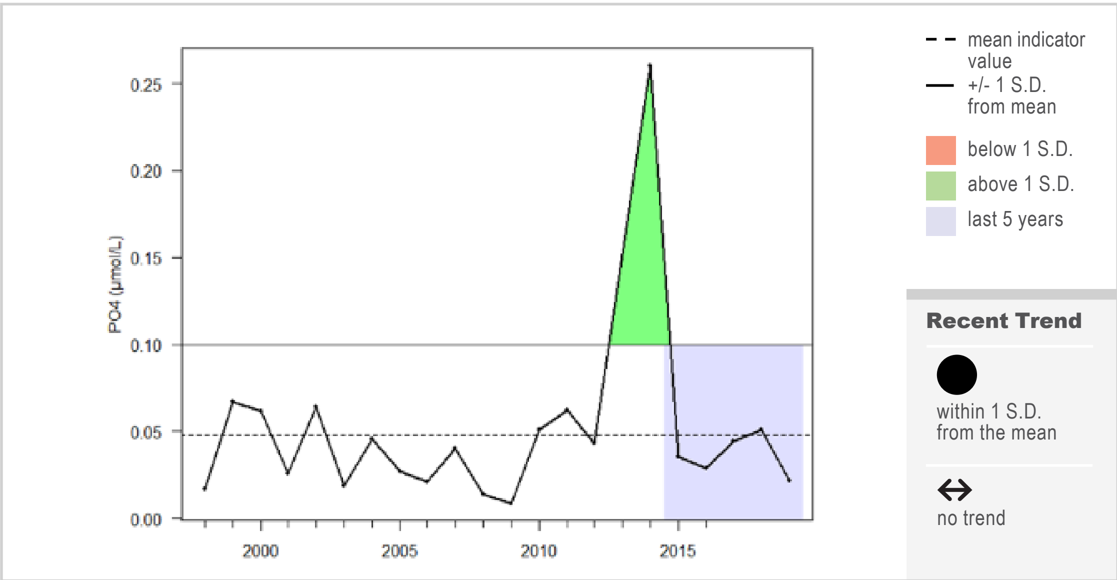

### *Total Tourism Value from Hospitality GDP*

**The last five years show a positive trend in total tourism value.**




### *Average DIP per Year*

**A peak in nutrient levels in Sanctuary waters in the last five years, followed by stabilization (Average level of phosphate for all Florida Keys stations, per year).**



# Methods

The indicator selection process consisted of five-steps (Figure 2). All five steps were conducted with significant collaboration and input from our management partners at FKNMS. The process was designed to harness expert opinion to both identify potential indicators and select the top indicators that best met agreed upon criteria. Thus, the indicator selection process centered around gathering expert opinion via a workshop and quantitative scoring of potential indicators against consensus criteria.

The indicator selection process began with a review of previous work on indicators in the region and indicator criteria from environmental studies across the globe (Doren et al. 2009, NCRMP Status Reports, MBON and Biodiversity Indicators Partnership, Miloslavich et al 2018, John et al 2014, Loomis et al. 2014). These local and global sources of information in conjunction with the characteristics required for informing a sanctuary condition report resulted in a preliminary list of essential criteria that a potential indicator should meet to be usable and appropriate for the projects' needs.

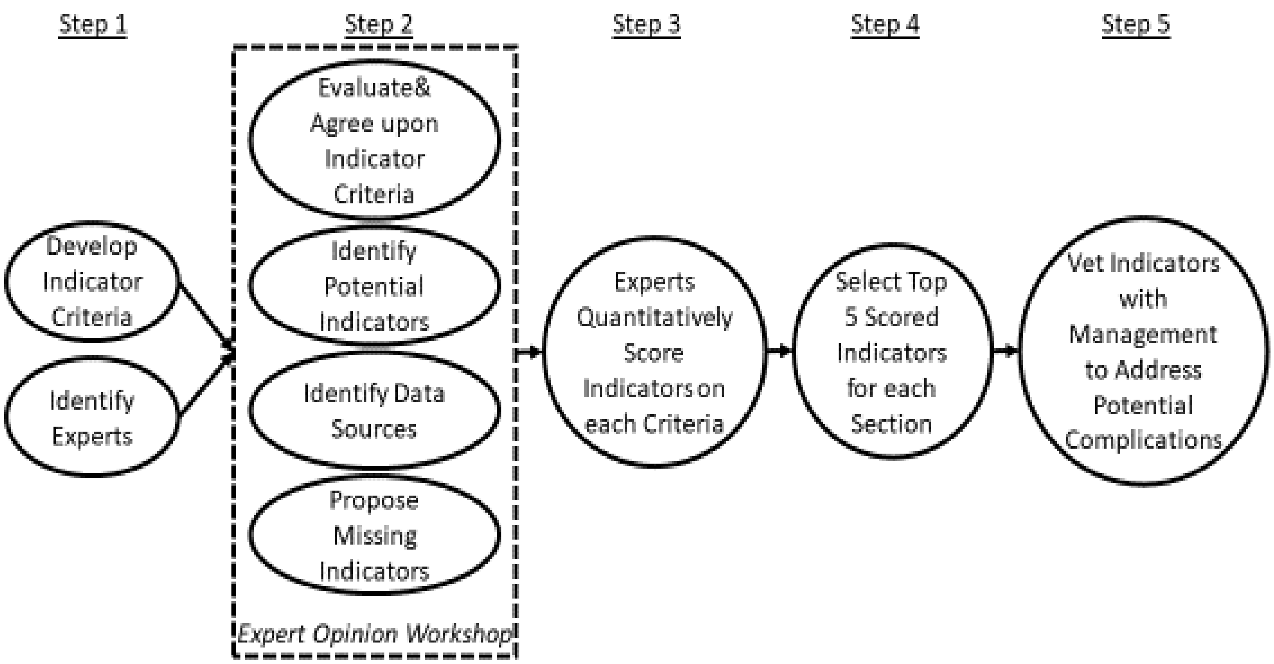



**Figure 2.** **The indicator selection process was 5 steps centered around an expert opinion workshop and frequent collaboration with the resource managers that intended to use the indicators during all five steps.**

The group discussed a suite of qualities that make an ecological indicator an appropriate representation of ecological condition. The decided upon criteria were: long term data availability, importance to ecosystem and culture, responsiveness to changes in environmental conditions, measurability, relevance to Sanctuary Condition Report questions, and responsiveness to management actions.

### *Goal*

The overarching goal of the expert workshop was to garner expert opinion, advice and feedback for selection of proposed ecological and socioeconomic indicators of the health of the Florida Keys National Marine Sanctuary.

### *Objectives*

The objectives of the workshop were to:

1. Reach a consensus on what makes a good indicator for this process, including the relevant criteria.
2. Develop a comprehensive list of proposed indicators.
3. Identify existing data sources and gaps.
4. Propose "missing indicators" that do not currently have sufficient data, but should be considered for the future.

# Indicator Selection

The workshop began with an introduction of the Integrated Ecosystem Assessment approach and needs of FKNMS, including a discussion of threshold analysis and indicator criteria. An orientation was given to the purpose of condition reports for National Marine Sanctuaries. The experts were then given time to refine the indicator criteria and agree upon the criteria that should be used henceforth to evaluate the proposed indicators. The experts were each assigned to a breakout group based upon their expertise relating to the sections of the ONMS condition reports (https://sanctuaries.noaa.gov/science/condition/). In the breakout groups, experts first discussed a prepared, pre-researched list of possible indicators relevant to their ONMS condition report questions. These initial proposed indicators were intended as a "straw man" for each group to add and remove proposed indicators. Then, the group reviewed data sources, gaps and proposed "missing indicators." All breakout groups came together and a member from each group presented their proposed indicators to the group as a whole, which allowed for discussion of proposed indicators, data sources and gaps, and "missing indicators" with all fields of expertise. The final product was a comprehensive list of proposed indicators.

## Scoring and Weighting Indicators

Using the indicator criteria agreed upon at the expert workshop, a decision matrix was created that allowed for each expert to score each proposed indicator across the criteria

**FKNMS Ecosystem Indicators Workshop Decision Matrix**

Developed by Kelly Montenero and Chris Kelble

| | Decision Criteria | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Decision Criteria*** | Long term data availability | Importance to Ecosystem & Culture (keystone, architect, poster-child) | Responsiveness to Environmental changes | Measurable-ness | Relevance to Sanctuary condition report Question 9- are other stressors affecting water quality? | Responsiveness to management actions | | **Criteria Weights Menu** | | **Indicator Options Score Menu** | |
| ***Set Criteria Weight*** | 5 | 4 | 3 | 2 | 4 | 4 | **Total** | 1 | less important criteria | 0 | Not suitable |
| **Proposed Indicator 1** | | | | | | | 0 | 2 | | 3 | Low |
| **Proposed Indicator 2** | | | | | | | 0 | 3 | | 6 | Mid |
| **Proposed Indicator 3** | | | | | | | 0 | 4 | | 9 | High |
| **Proposed Indicator 4** | | | | | | | 0 | 5 | important criteria | | |
| **Proposed Indicator 5** | | | | | | | 0 | | | | |

Project Weighting - Project weights for each criteria should be 0 (Not suitable), 1 (Low), 3 (Mid), 9 (High)

**Figure 3.** **Example blank decision matrix from Step 3.**

and weight the criteria if they desired criteria to have different weights (Figure 3). The decision matrix enables the collection of quantitative data from experts individually on how well each proposed indicator meets each of the criteria. These individual scores can then be analyzed together to determine the group score for the proposed indicators' fit to the criteria along with relative weights for each criterion. The process thus allows for both group rationale and individual input, without succumbing to the lengthy rehashing and indicator "championing" problems that have arisen in similar group consensus processes (Lynham et al. 2017).

Experts were instructed at the workshop on how to score indicators and criteria using the decision matrix at the workshop and tasked with completing their decision matrices individually and electronically. To score the criteria, each individual assigned a "weight" of importance from 0-5 to each criterion from a drop down menu, a value of 5 representing the most important decision criterion and 0 representing no importance. The matrix allowed for values of criteria weights to be repeated; thus, it was not scored in rank order of importance, but by relative weight of importance. Then, experts selected a score of 0, 3, 6 or 9 from a drop down menu, in each cell of the matrix. The cell is the intersection of each proposed indicator with each decision criterion. The score represented how well the indicator met that criterion compared to other indicators. Scoring with 0, 3, 6 and 9 rather than linear integers was designed to allow for score clustering and a well-defined "winner" (Roche and Campagne 2019).

A decision matrix was created for each section. All decision matrices were then added as tabs on single spreadsheet workbook, to allow participants to view and score all of the proposed indicators in all sections. Participants were encouraged to score the proposed indicators for other sections if they felt they had expertise in other sections. The formulas built into the decision matrix calculate each proposed indicator's total score by multiplying the decision criteria weight and the indicator score. This creates a prioritized list per participant of top selected indicators.

## Ranking Indicators

All participant's scores were then combined by section, by assigning individual top ranks to each indicator based on top scores, and then calculating the top 5 indicators based on the calculated combined highest rank score per section. If two indicators were tied for the fifth rank, the section was allowed to have 6 selected indicators. This ranking technique was necessary due to the non-parametric nature of the number of proposed indicators and votes. This approach creates quantitative group consensus from individual scores via qualitative review (Campagne 2018).

## Identifying Data Sources

As one decision criteria in the decision matrix was the availability of long term data, each participant was also asked to identify data sources, contacts for potential data, and provide background rationale for their small group section's full list of proposed indicators. The information on data sources provided from experts was invaluable in confirming that top selected indicators could be assessed, and in streamlining efforts to collect data for the next steps in the indicator evaluation process.

## Selecting Indicators

After all experts had returned their completed decision matrices and the top scored indicators per section were calculated, the preliminary list of the top 5 to 6 (if there were tied scores) selected indicators in each section was sent to all participants for review to determine if the process resulted in any misgivings, misplaced section assignments, missing indicators, and counter-intuitive rationale. Any comments and concerns were then addressed and the list was revisited to ensure it reflected the group consensus.

After vetting the selected indicators with all participants, the list was then shared with partners at FKNMS for review of the above mentioned potential issues and, to ascertain that the selected indicators would fit the needs of the Sanctuary. Any concerns raised by FKNMS were then addressed and a finalized list of selected indicators was distributed and assessment of indicators commenced with the collation of data sources.

### *Decision Criteria Selected*

1. Long term data availability
2. Importance to ecosystem and culture
3. Responsiveness to changes in environmental conditions
4. Measurability
5. Relevance to Sanctuary Condition Report questions
6. Responsiveness to management actions

### Expert Participants

The group of experts who gathered to participate in the indicator selection workshop numbered 27 and were invited based on their knowledge of the region and familiarity and access to large continuous datasets, and every effort was made to be sure experts represented both the sections of the condition report and the different habitats of the Sanctuary. Those experts who were identified as missing and unable to attend were later included remotely via presentations and conference calls, and also submitted scored decision matrices. Sectors participating included federal government research and monitoring, federal fisheries resource managers, state aquatic resource and fish and wildlife resource managers, national park managers and scientists, non-governmental environmental resource and fishing experts, academic researchers, human dimensions socioecologists, ecosystem modelers, and marine archaeologists.

### Prioritized List of Indicators

After individual rank scoring of proposed indicators by experts in each field according to best fit of each decision criterion and then combined rank scoring per each section, the resulting prioritized list of selected indicators of the health and condition of Florida Keys National Marine Sanctuary is represented in the following sections.

### Data and Graphs

Data per selected indicator were mined, sourced or extracted from publically accessible recommended sources via expert workshop feedback. These sources included NOAA, academic, agency, state, tourism bureau, county and other sources. The data were formatted, sorted and refined when necessary in order to compare conditions through time, as consistent and as long-term as possible. When necessary, descriptive statistics were used to condense data and compare parameters.

These data were then graphed in order to discern status and trends through time, per section and per indicator. Excel and R studio were used to describe the following suite of indicator status and trends of the condition of the Florida Keys National Marine Sanctuary. The following graphs illustrate the mean indicator value, standard deviation of the mean, and a simple recent trend analysis for each indicator of the last five years, when possible (Figure 4). Arrows per graph indicate if the slope is greater than 1 standard deviation, less than one standard deviation, or no trend (Karnauskas et al. 2017).

The x-axis represents the temporal dimension, which may be monthly or yearly 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 time periods for which the indicator value is below or above one standard deviation from the mean, respectively. The lavender 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) (Figure 5). Multi-panel plots are used to show trends in the same indicator, calculated for different species or over different spatial domains.

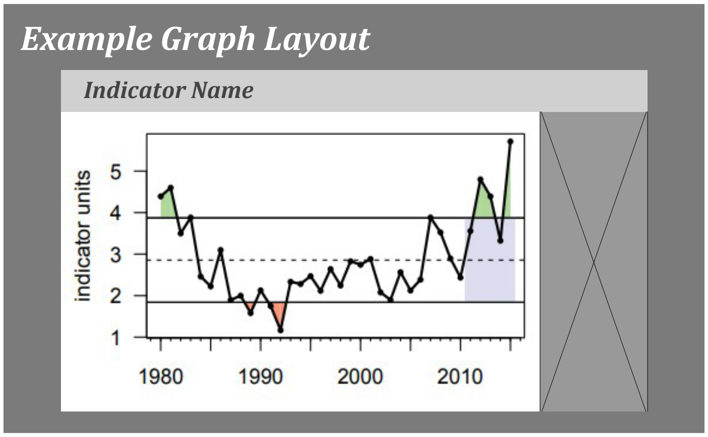



**Figure 4.** Explanation of graph layout.

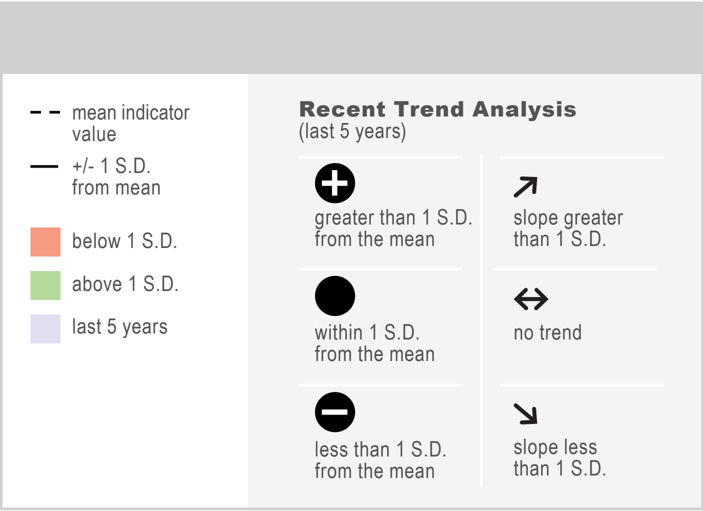



**Figure 5.** Explanation of symbol key.

# Status and Trends of Indicators

## Human Activities

Experts identified and selected the following indicators in the Human Activities section: Resident population, tourism visitation, cruise ship passenger visits, wastewater and stormwater management, number of commercial and recreational vessels by registration, the amount of commercial fishing trips taken, and the number of commercial fisheries trips and landings of the following economically important species — grouper, snapper, lobster, and stone crab. These indicators were top scored according to the criteria and considered most influential human activities affecting the condition of the ecosystem. See data sources section for more information.

### Resident Population

Resident population data was chosen to illustrate how this pressure has changed in Monroe County, especially important in a land-limited area where human population put a direct strain on the natural habitats and resources. The population increased (greater than 1 standard deviation from the mean) dramatically from the 1940 to the current total population of 77,304, though the population change in the last 5 years shows no trend (Figure 6).

***Resident Population in Monroe County***

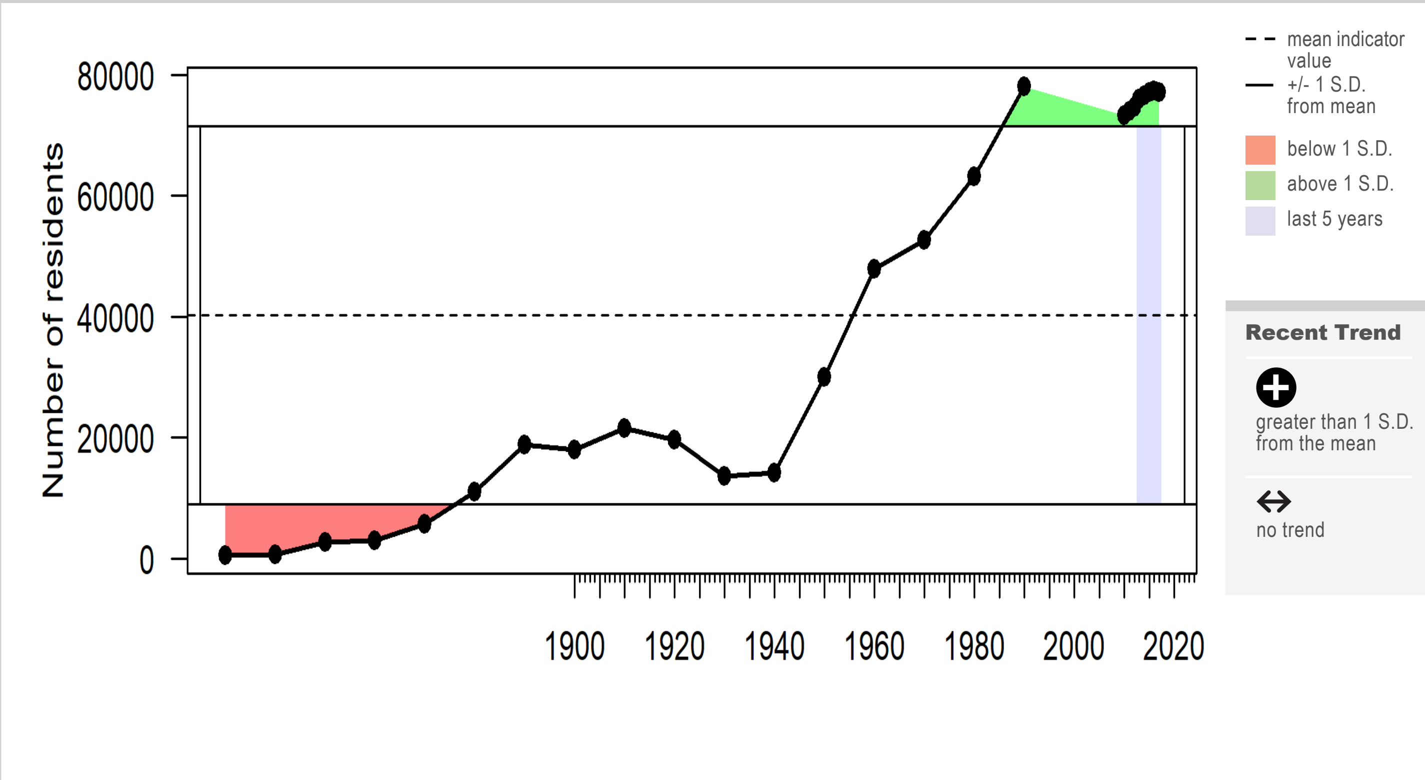



**Figure 6. Resident Population Trends in Monroe County. Over the last 5 years the number of residents has stayed within 1 standard deviation from the mean and no trend.**

## Tourism Visitation Trends via Tax Revenue

Though experts agreed that tourism visitation was an important indicator, data on this metric was surprisingly hard to come by, due to the need to capture all types of overnight visitors, day trip visitors, both in state and out of state visitors, and international as well as domestic visitors. Additionally, each municipality has a different method of recording number of visitors. Thus, this study was recommended to review trends in the tourist tax revenue (a collection of 4-5% tourist development taxes for public funding) collected as a proxy to capture the longest time series trends in all categories of visitors. Data was adjusted to reflect changes through time in the percentage of tax levied. Since 2011, visitation has been more than 1 standard deviation from the mean, though a recent decrease occurred in 2017 due to Hurricane Irma making landfall in the Lower Keys (Figure 7).

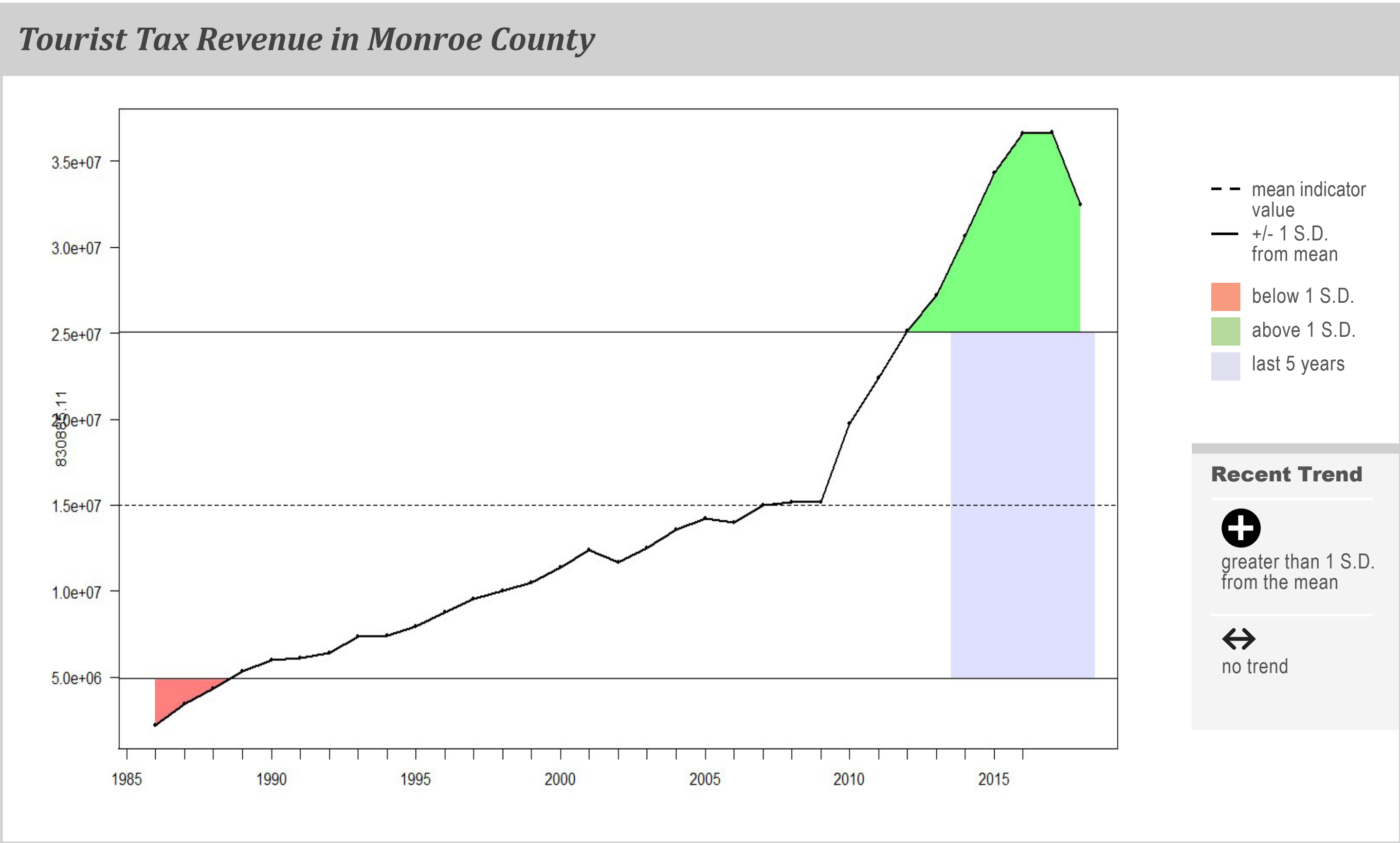



**Figure 7.** **Tourism Visitation Trends via county tourist tax revenue.**

## Cruise Ship Passenger Trends

The number of cruise ship passengers who visited Key West was selected as an indicator by our expert workshop, which represents not only day trippers/non-hotel staying visitors, but also the additional pressures of cruise ships traveling through sanctuary waters and habitats (Figure 8).

*Cruise Passenger Visits to Key West*

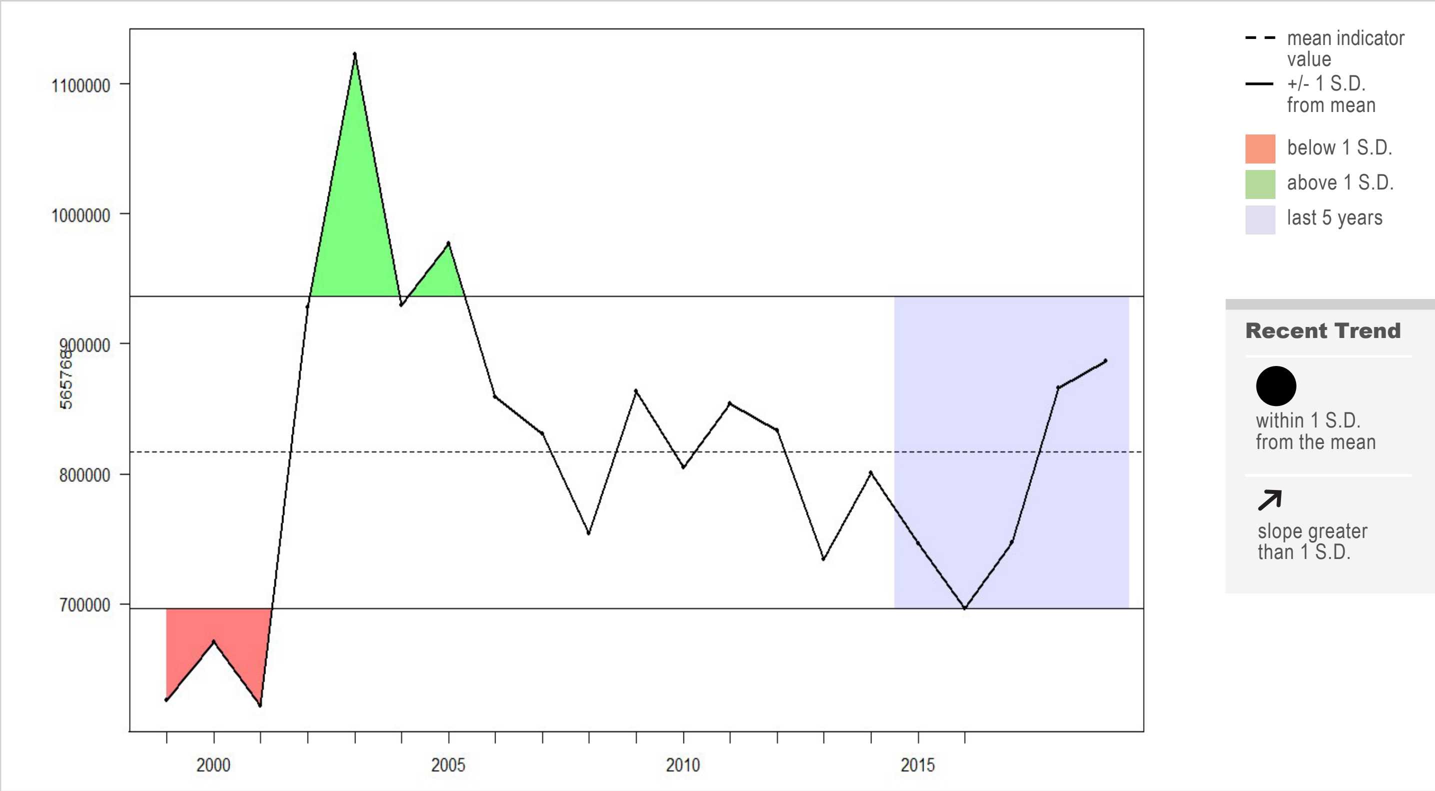



**Figure 8.** **Cruise ship passenger visits to Key West.**

## Number of Stormwater and Wastewater Management Actions Implemented

As the Florida Keys are an island chain between the Gulf of Mexico and the Florida Straits of the Atlantic, management of sewage and wastewater was determined to be an important indicator of how human activites and presence put pressure on the ecosystem condition. A major effort was undertaken in the Keys to connect all household to a central sewer system rather than using cesspits, septic tanks and other individual wastewater containment susceptible to damage and leakage of wastewater into Sanctuary waters. In the last five years, almost all household have been connected to the central sewer system, a human management activity that reduces pressure on Sanctuary condition and resources (Figure 9).

*Percent of Households Connected to Sewer System*

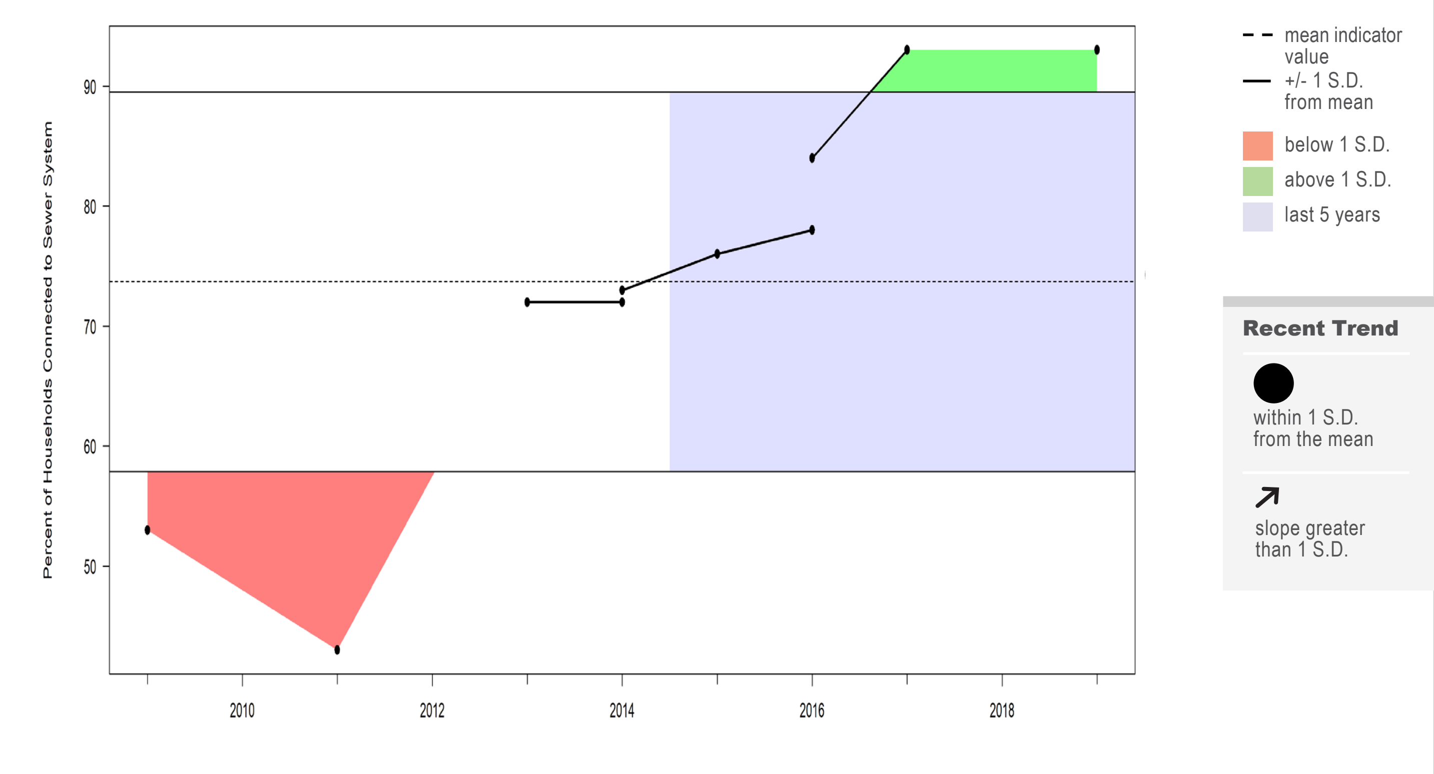
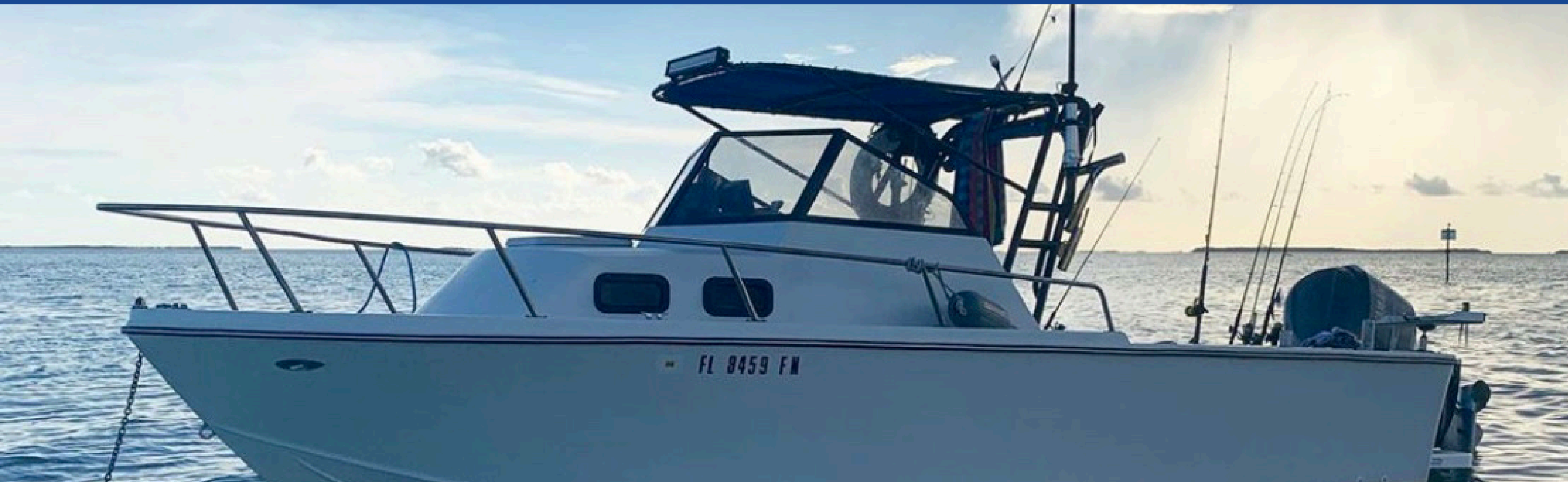



**Figure 9.** **Percentage of Total Equivalent Dwelling Unit Connected to Wastewater System, Florida Keys.**




## Number of Recreational and Commercial Vessels by Registration

The number of combined recreational and commercial vessels registered by the Florida Department of Highway Safety and Motor Vehicles saw a drop of more than one standard deviation below the mean recession in 2008, recovering in 2013. This trend likely corresponds to the financial recession in 2008 and subsequent recovery. The last five years had an increasing trend of more than one standard deviation. This decrease and following increase in registered vessels in Monroe County could result in additional pressure on sanctuary resources, as new boaters may not have the appropriate historical knowledge of navigation as well as protected zones in the sanctuary.

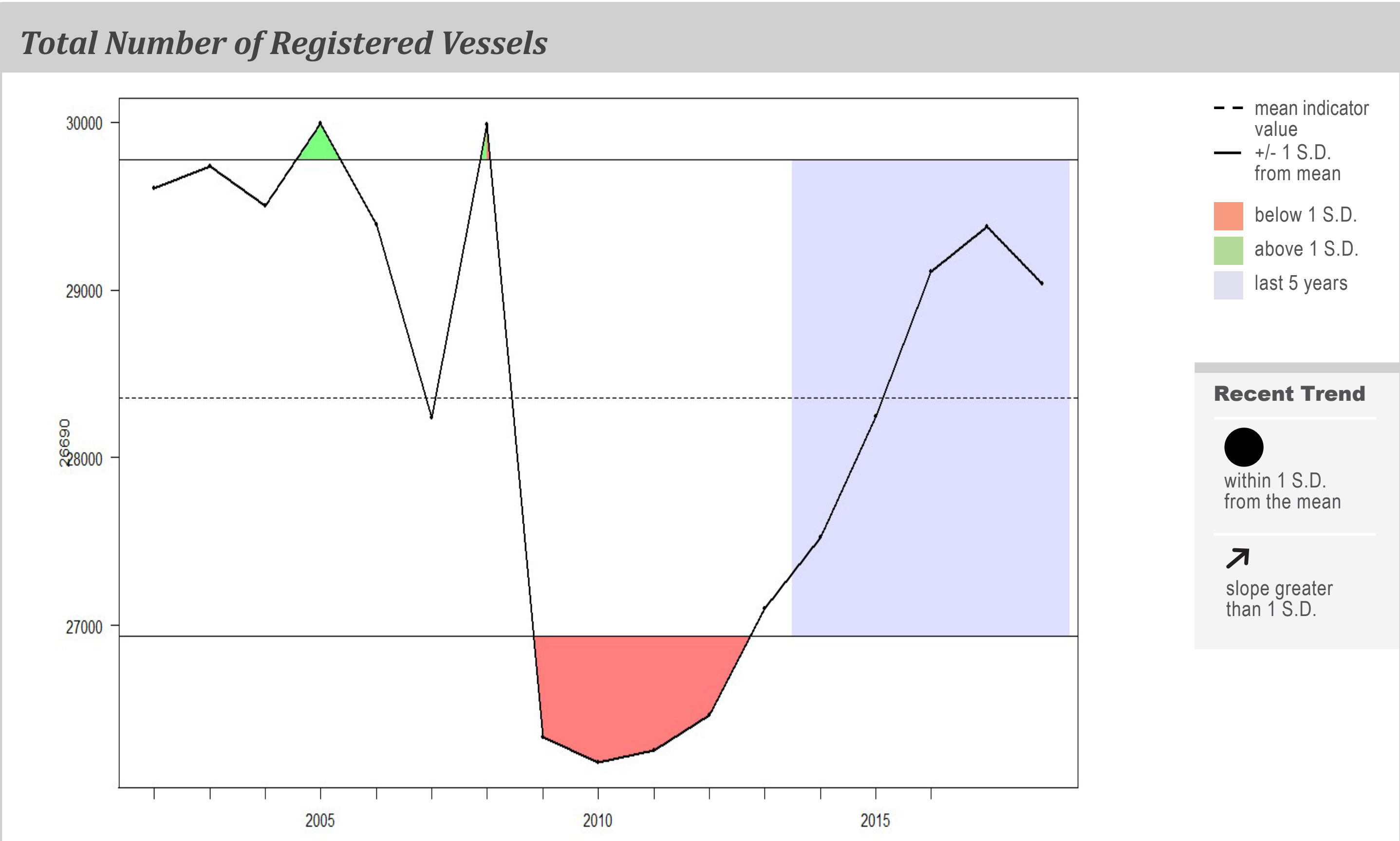



**Figure 10.** **Total number of registered vessels in Monroe County, including recreational and commercial.**

## Number of Boating Enforcement Actions

In Figure 11, an overall increase in the amount of boating enforcement actions by the sanctuary and partners could result from this lack of historical knowledge, though this trend may also be due to changing presence and availability of law enforcement.

***Total Boating Enforcement Citations and Warnings in Sanctuary***

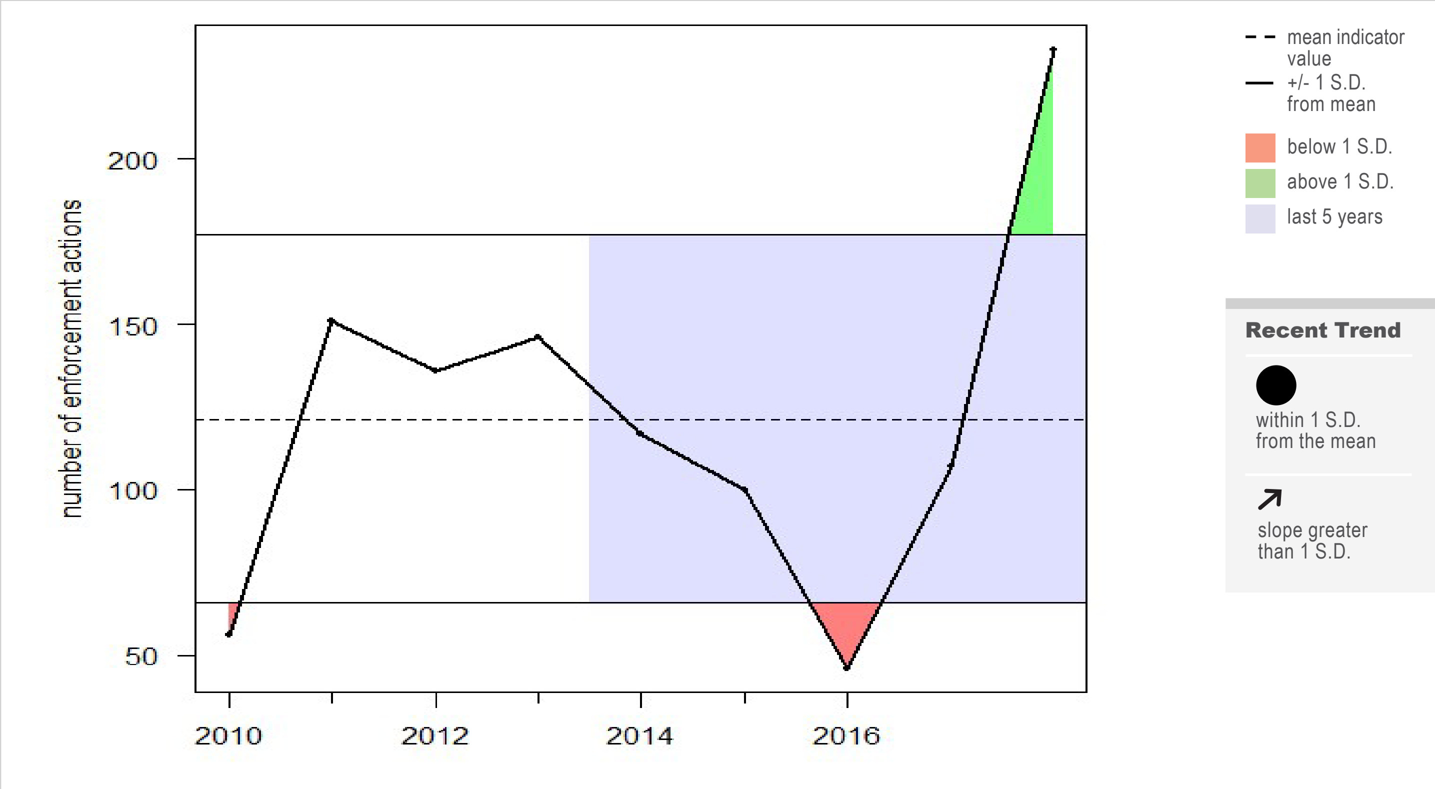



**Figure 11.** **Total number of boating enforcement actions taken in the Sanctuary.**

## Number of Commercial Fishing Trip Tickets

Measuring the total amount of commercial fishing trips that is landed on sanctuary shores and transits and fishes in sanctuary waters was considered an important indicator in both the Human Activities and Ecosystem Services sections. This data, gathered from the Florida Fish and Wildlife Conservation Commission, shows a low amount of total commercial fishing trips in 1998, rapidly increasing to a peak in 1999, followed by a significant drop in 2008. The last five years show trends not different from the overall mean for this time period (Figure 12).

### *Commercial Fishing Activity*

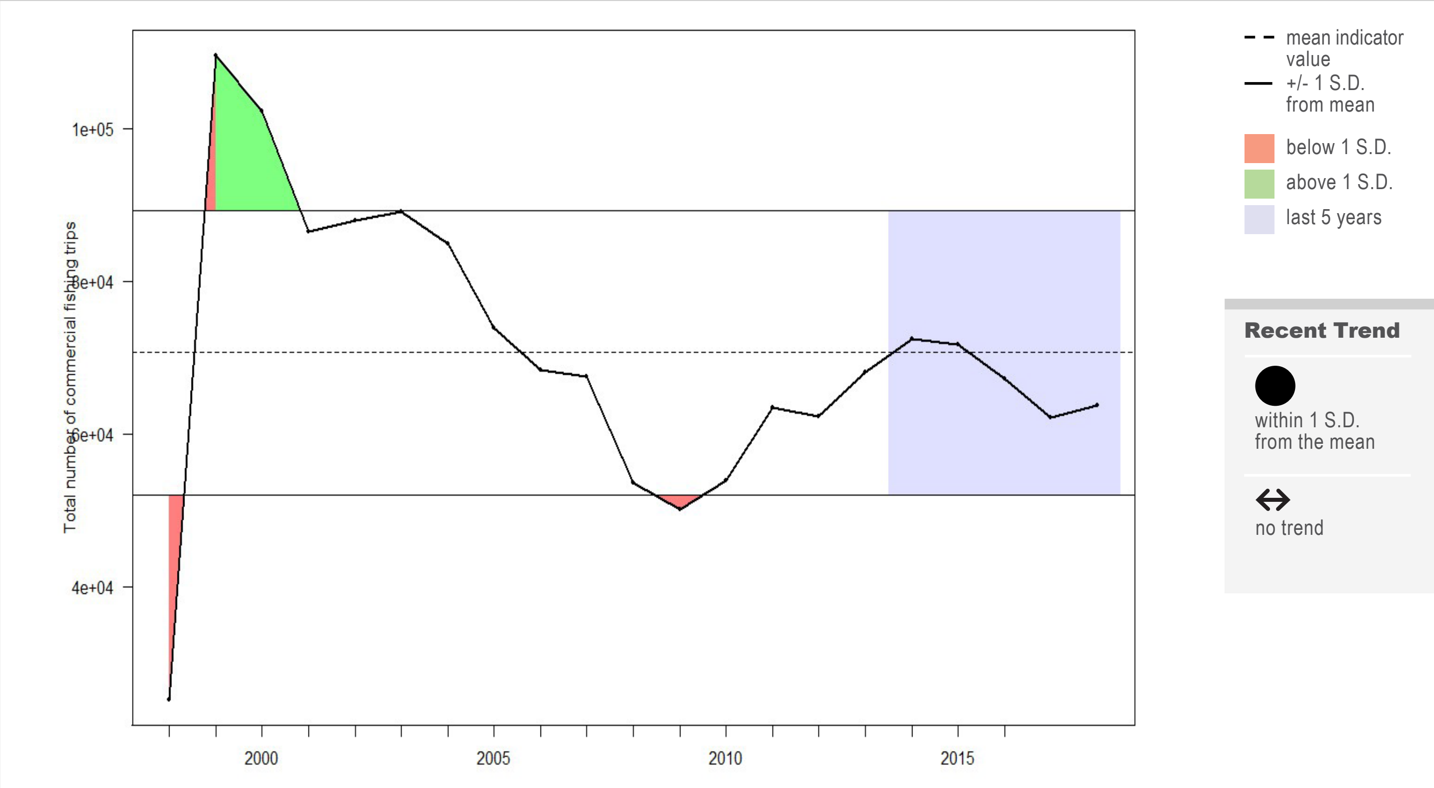



**Figure 12.** **Total number of commercial fishing trips from the Florida Keys.**

## Fishing Trips of Identified Economically Important Species

Measuring the amount of commercial fishing trips targeting identified economically important species that is landed on sanctuary shores and transits and fishes in sanctuary waters was also considered an important indicator in both the Human Activities and Ecosystem Services sections. The selected economically important species referred to data collected by Florida Fish and Wildlife Conservation Commission and NOAA National Marine Fisheries Service, showing the number of trips of the top four fish groups for revenue: all groupers (Figure 13), all snappers (Figure 14), all lobster (Figure 15) and stone crab (Figure 16). Declining trends were seen in the number of lobster trips in the past five years, and all fisheries experienced declines below one standard deviation for some period since 2008.

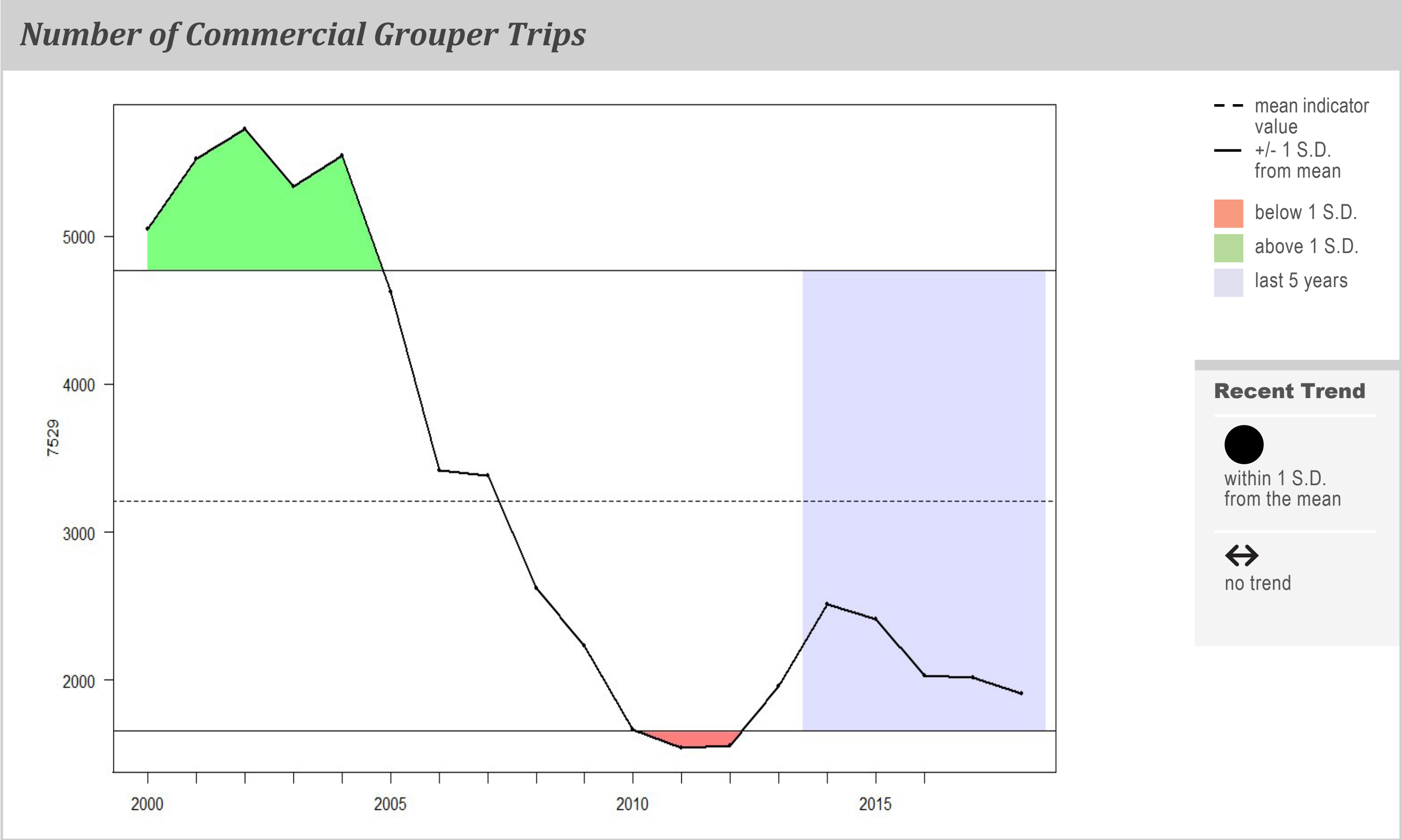



**Figure 13.** Number of grouper commercial fishing trips from the Florida Keys.

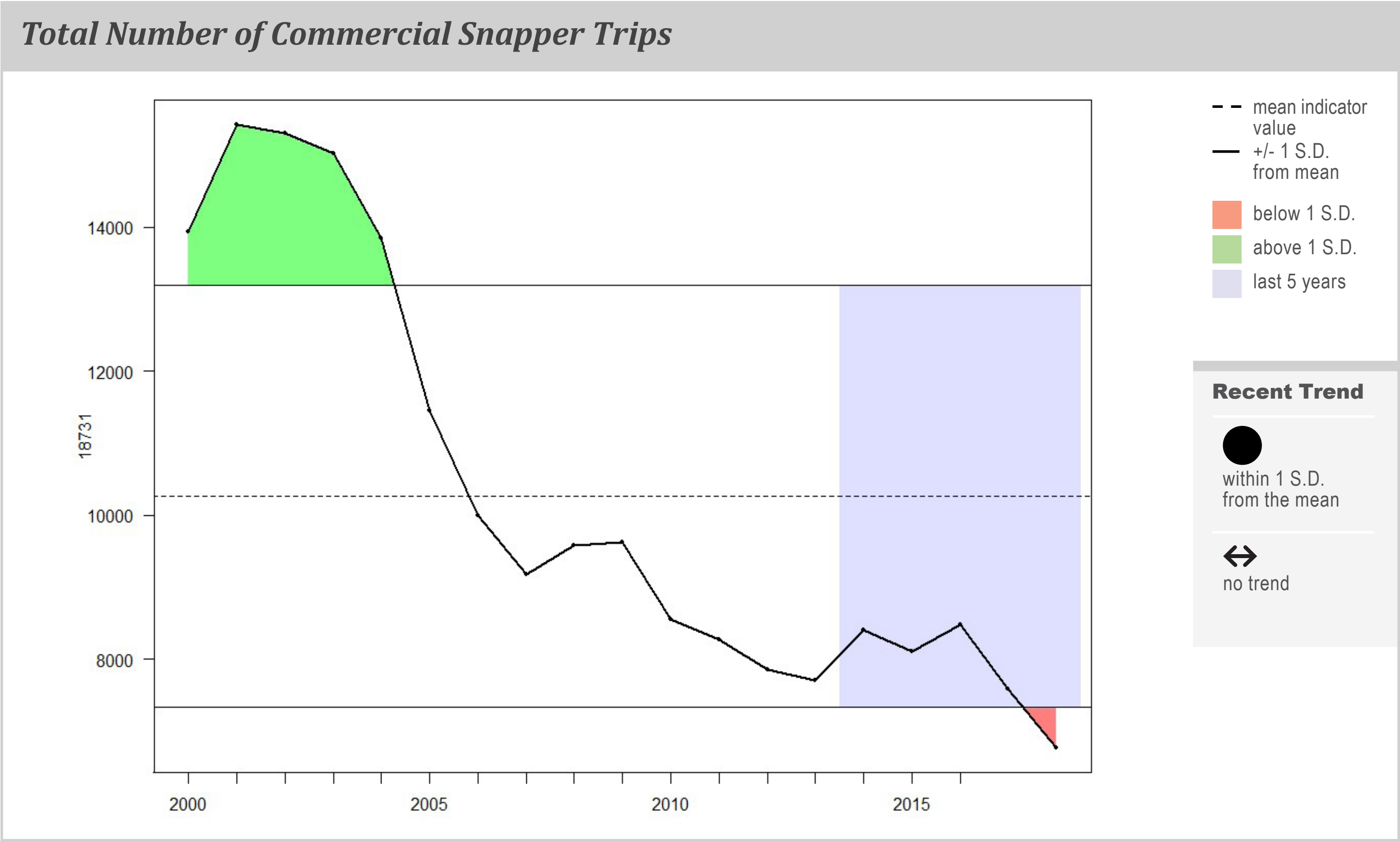



**Figure 14.** Number of snapper commercial fishing trips from the Florida Keys.

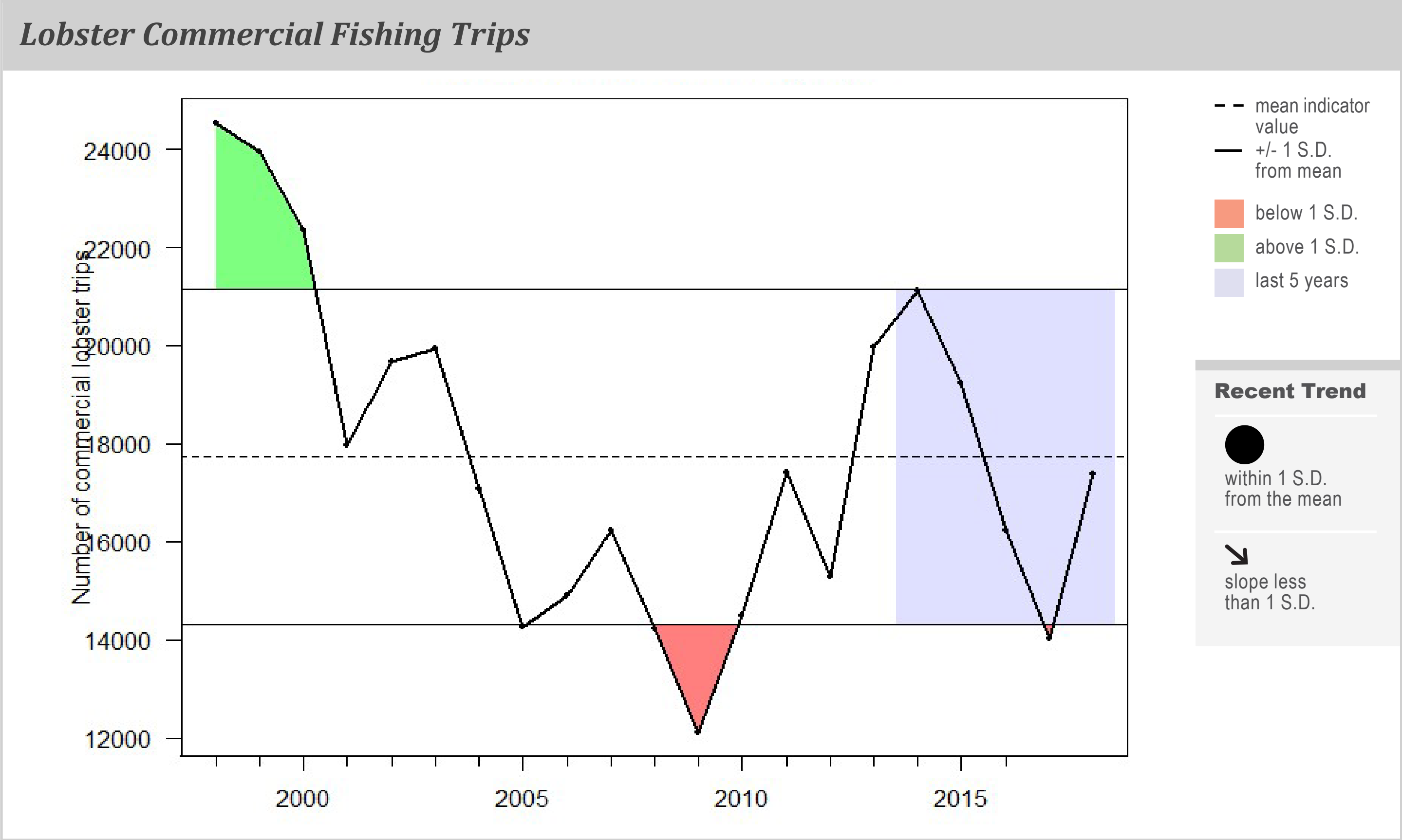



**Figure 15.** Number of lobster commercial fishing trips from the Florida Keys.

## Stone Crab Trips

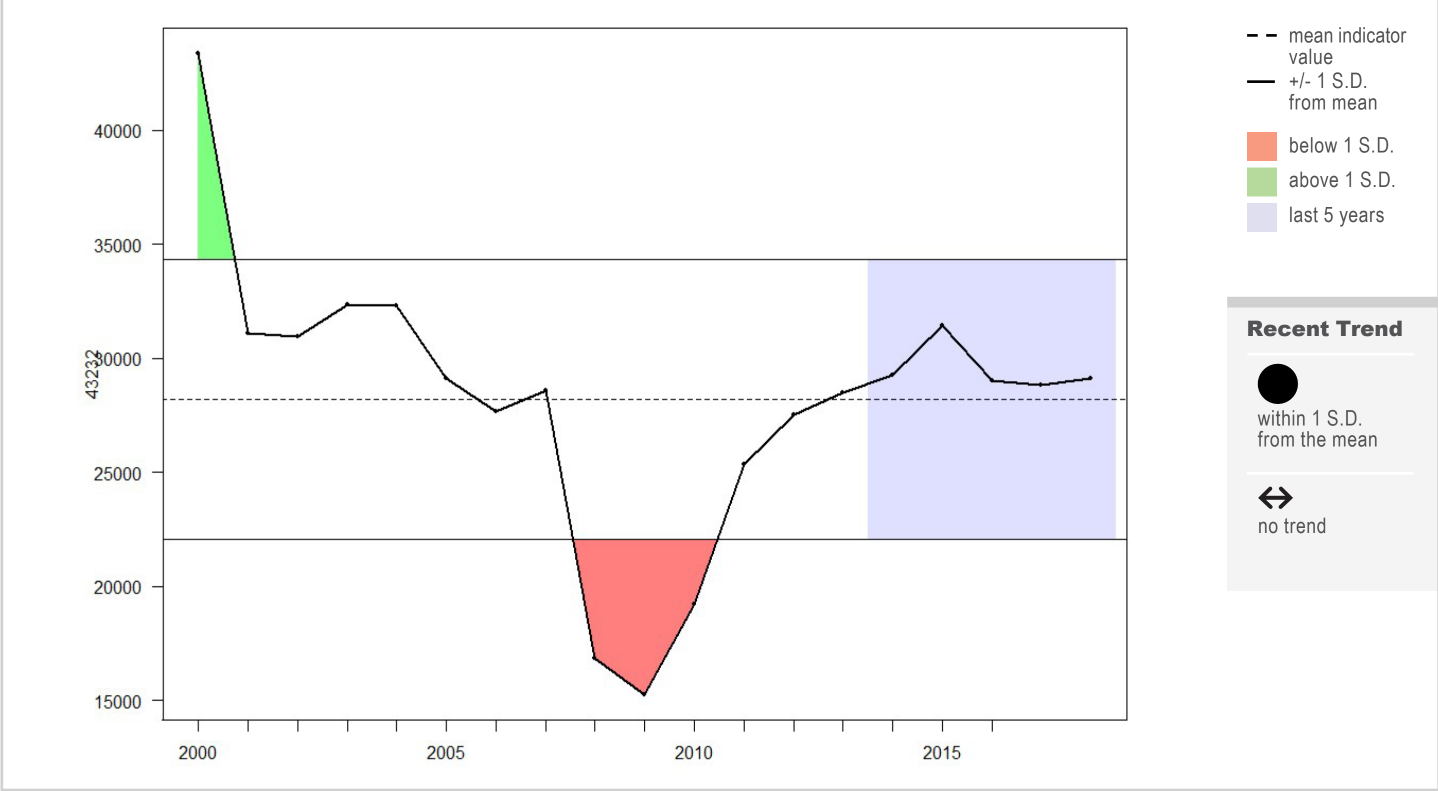



**Figure 16.** Number of stone crab commercial fishing trips from the Florida Keys.

# Ecosystem Services

The National Marine Sanctuary system defines Ecosystem Services as "benefits humans derive from nature" (National Marine Sanctuaries Condition Reports). These benefits are considered ecosystem services when directly related to people, such as through use, consumption, enjoyment, and/or knowing these resources exist. Ecosystem Services are considered in relation to cultural, provisioning, and buffering benefits. Thus, recreational fishing activity, engagement and reliance, commercial landings, coastal protection via mangrove and reef structures, total tourism value, and housing disruption were considered as key indicators of the benefits provided by ecosystem services in this report.

## Total Recreational Fishing Licenses Sold in Monroe County

The Florida Keys are known and marketed as the "Sport Fishing Capital of the World". Recreational fishing is vastly important as an economic driver as well as a source of food for residents. Recreational fishing licenses sold in Monroe County, Florida, and reliance and engagement on recreational fishing are thus a useful indicators of this ecosystem service. The number of licenses sold has been in decline since 2014, and has been more than one standard deviation below the mean since 2018 (Figure 17). This data set was only available since 2008, when online sales were first available.

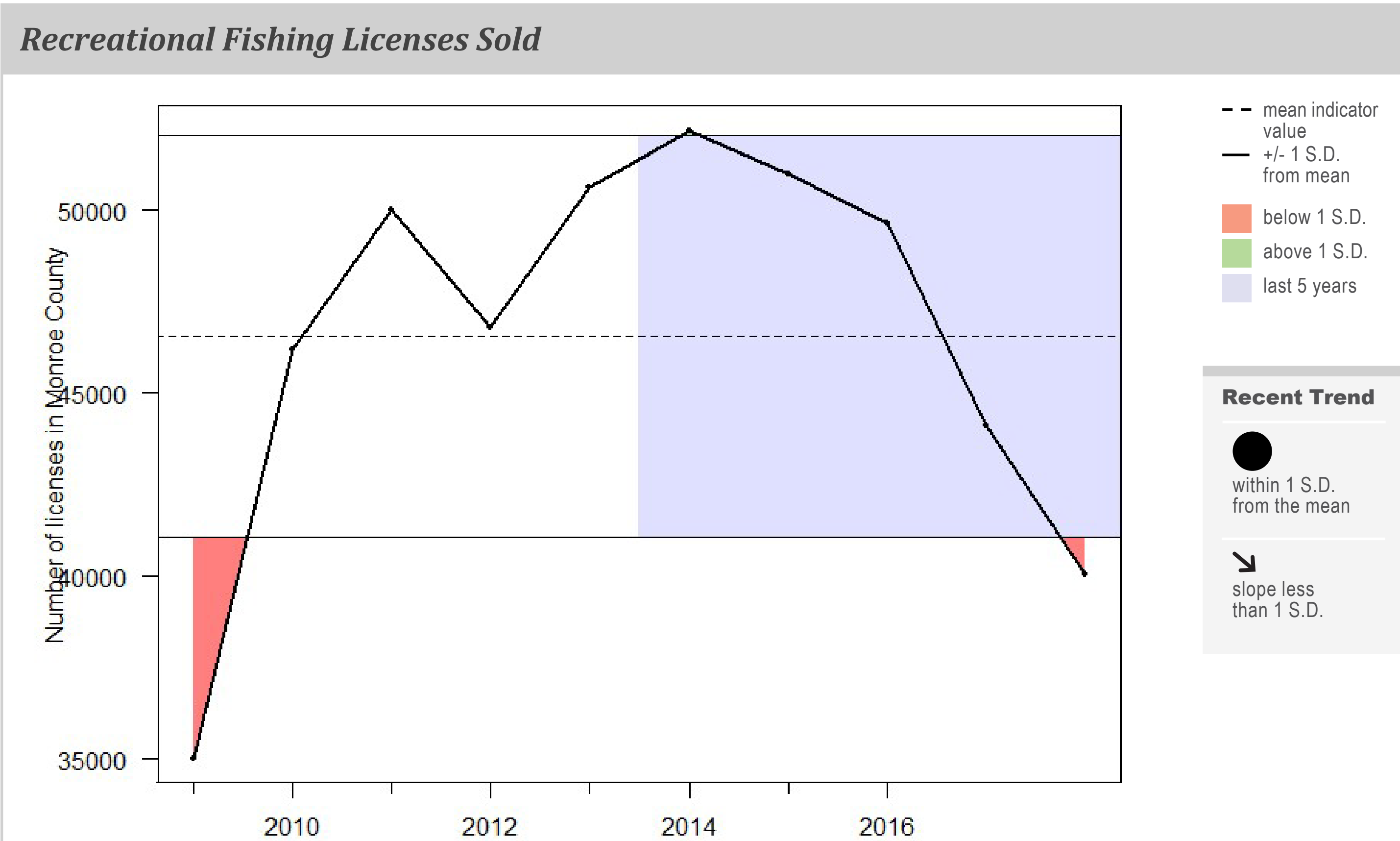



**Figure 17.** **Number of recreational fishing licenses sold in Monroe County, Florida.**

## Recreational Fishing Engagement

Engagement in recreational fishing in the Florida Keys is medium high to high for residents of almost all major municipalities, (Figure 18) and reliance on recreational fishing was medium high in most major municipalities in the Keys (Figure 19) according to NOAA Office of Science and Technology's coastal social vulnerability survey in 2017.

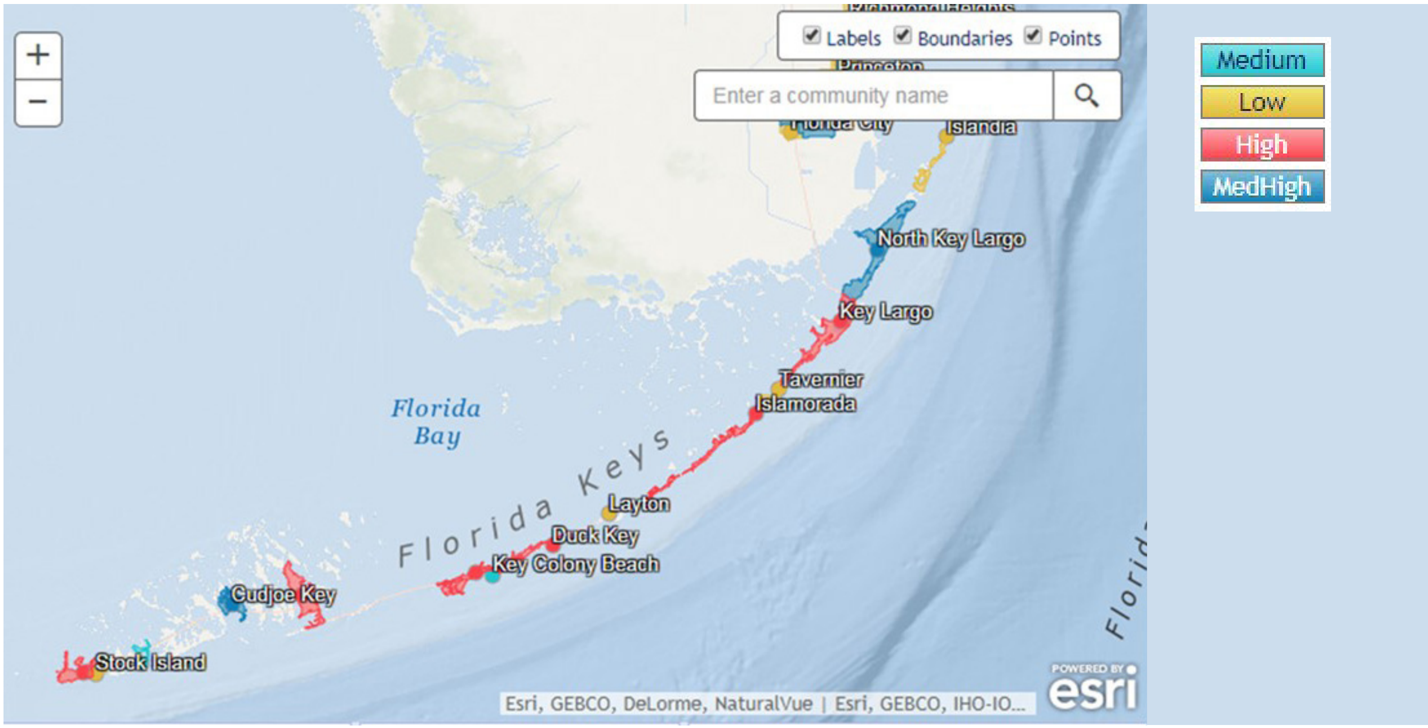



**Figure 18.** **Engagement in recreational fishing per municipalities of the Florida Keys, 2016.**

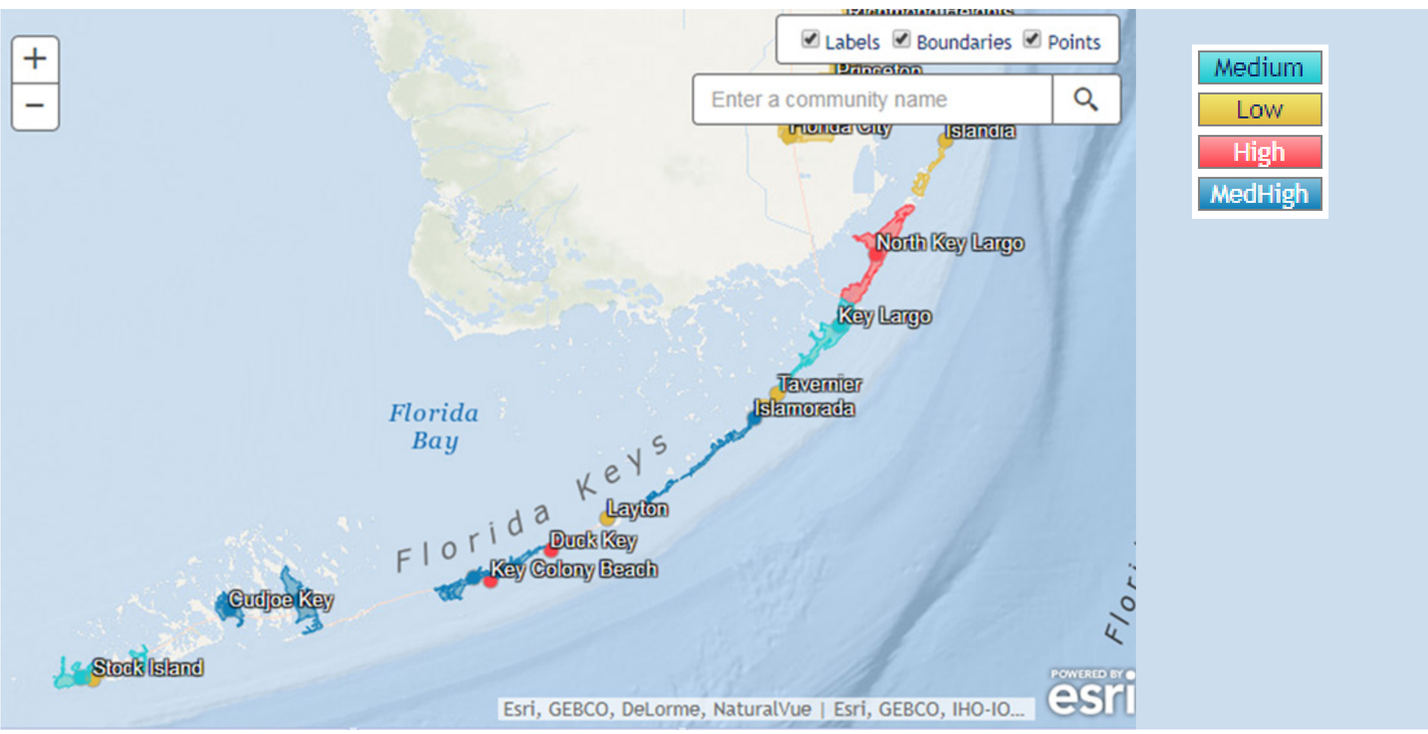



**Figure 19.** **Reliance on recreational fishing per municipalities of the Florida Keys, 2016.**

**Florida stone crab. Credit: Florida Fish and Wildlife**

## Commercial Landings of Economically Important Species (see Human Activities for Trips)

The commercial landings per pound of the top four most valuable and most often targeted species were graphed and analyzed. All snapper species (Figure 23), all grouper species (Figure 21), lobster (Figure 22) and stone crab fisheries (Figure 20) were determined to be the most economically important for the Florida Keys. All fisheries experienced a drop in 2008-2010, likely due to the recession, and have not returned to pre-recession levels of landings. Each fishery experienced different amounts of variability, but all four have not had significant upward or downward trends in the last 5 years.

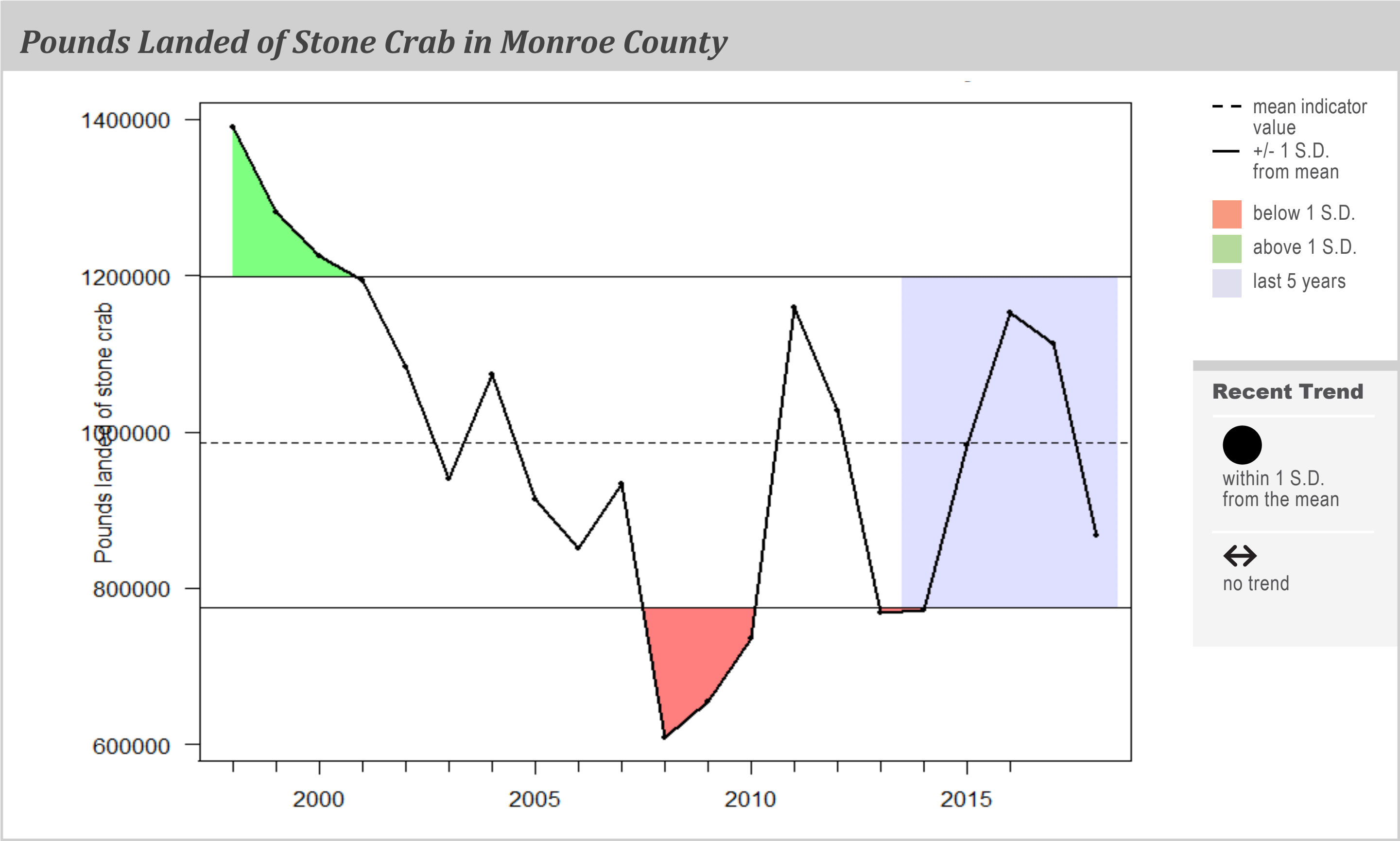



**Figure 20.** **Pounds of stone crab landed in Monroe County.**

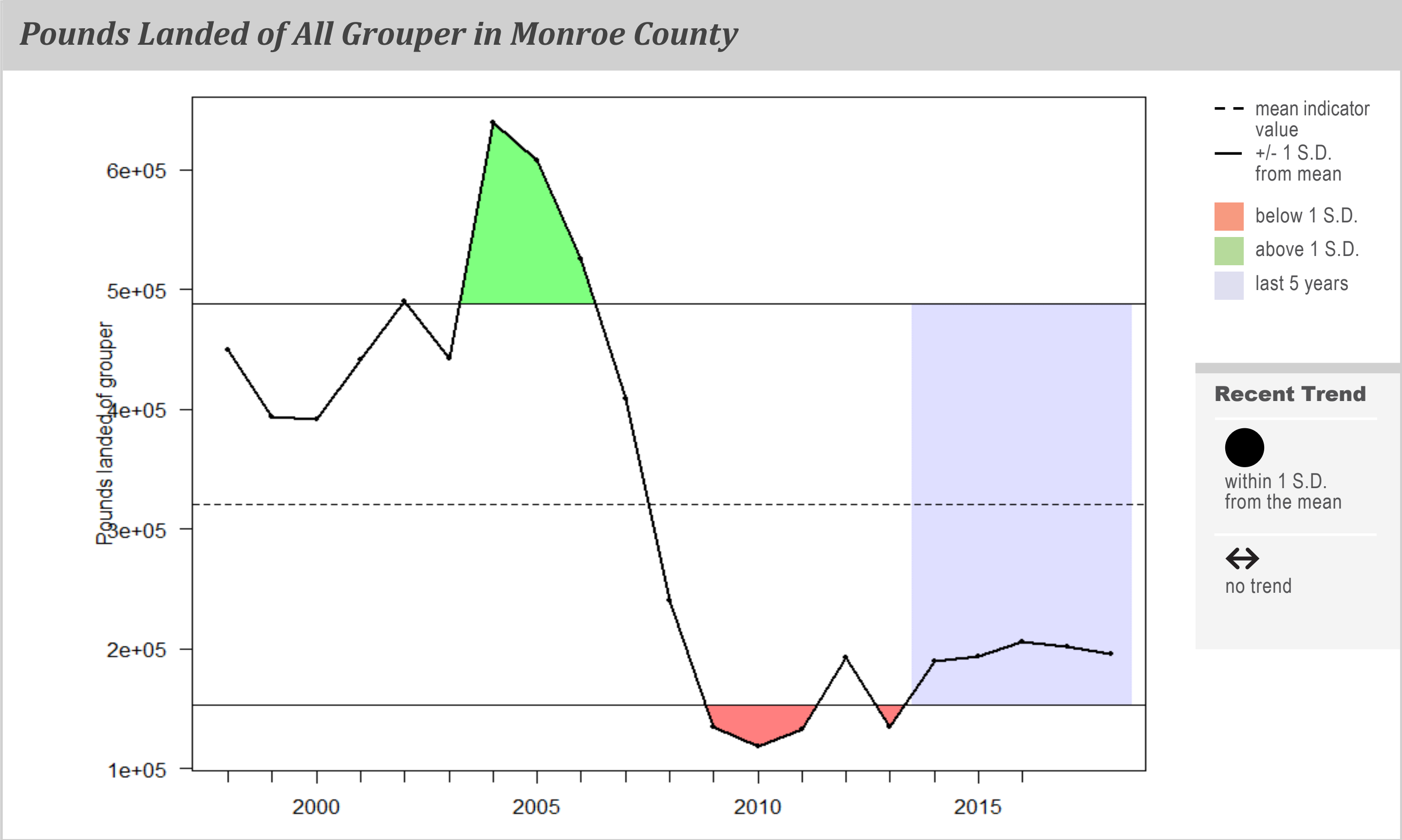



**Figure 21.** Pounds of all grouper landed in Monroe County.

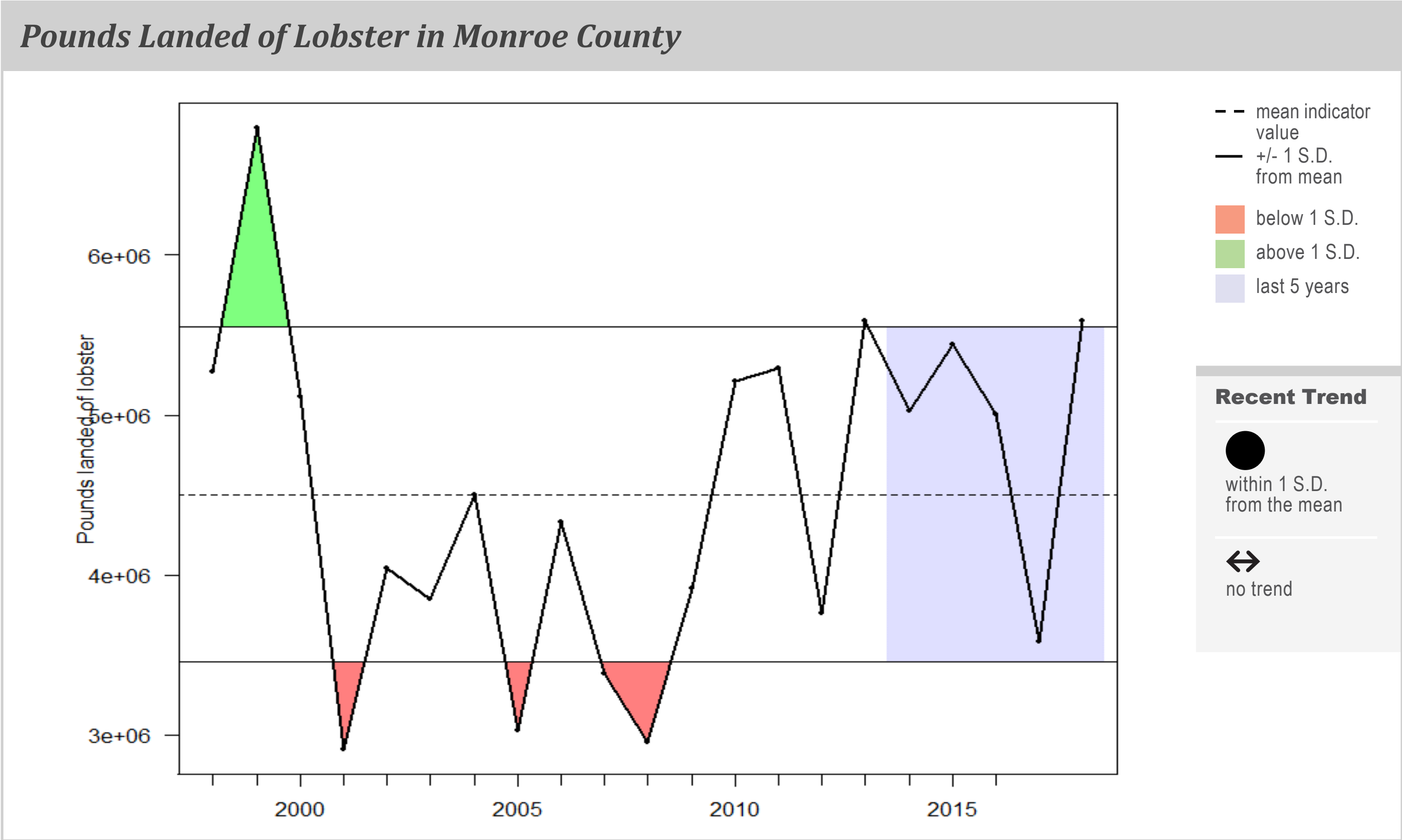



**Figure 22.** Pounds of lobster landed in Monroe County.

*Pounds Landed of All Snapper in Monroe County*

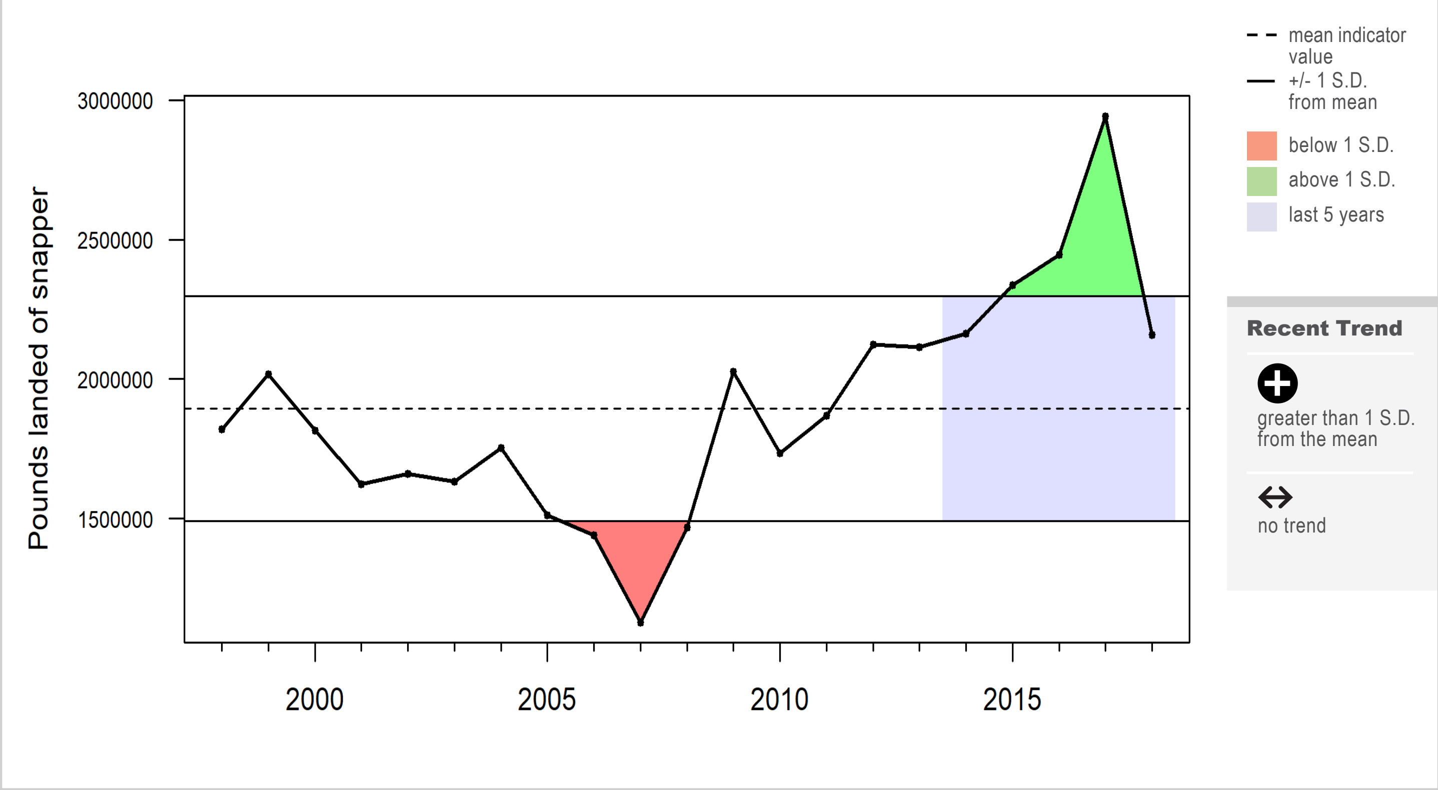



**Figure 23.** **Pounds of all snapper landed in Monroe County.**

## Coastal Protection by Mangroves and Reef Structure

Important ecosystem services are provided by mangroves and coral reef structure in the form of coastal protection. Both mangrove lined shorelines and coral reef structure provide important wave attenuation and storm surge mitigation during storms and extreme events (Guannel et al. 2016; Kandasamay 2005), more so when both living habitat structures exist in the same location. Land cover changes in developed verses undeveloped land (Figure 24 and 26), changes in forested wetland coastal cover (Figure 25), and the value of coastal protection by reef structure are shown here (Figure 27).

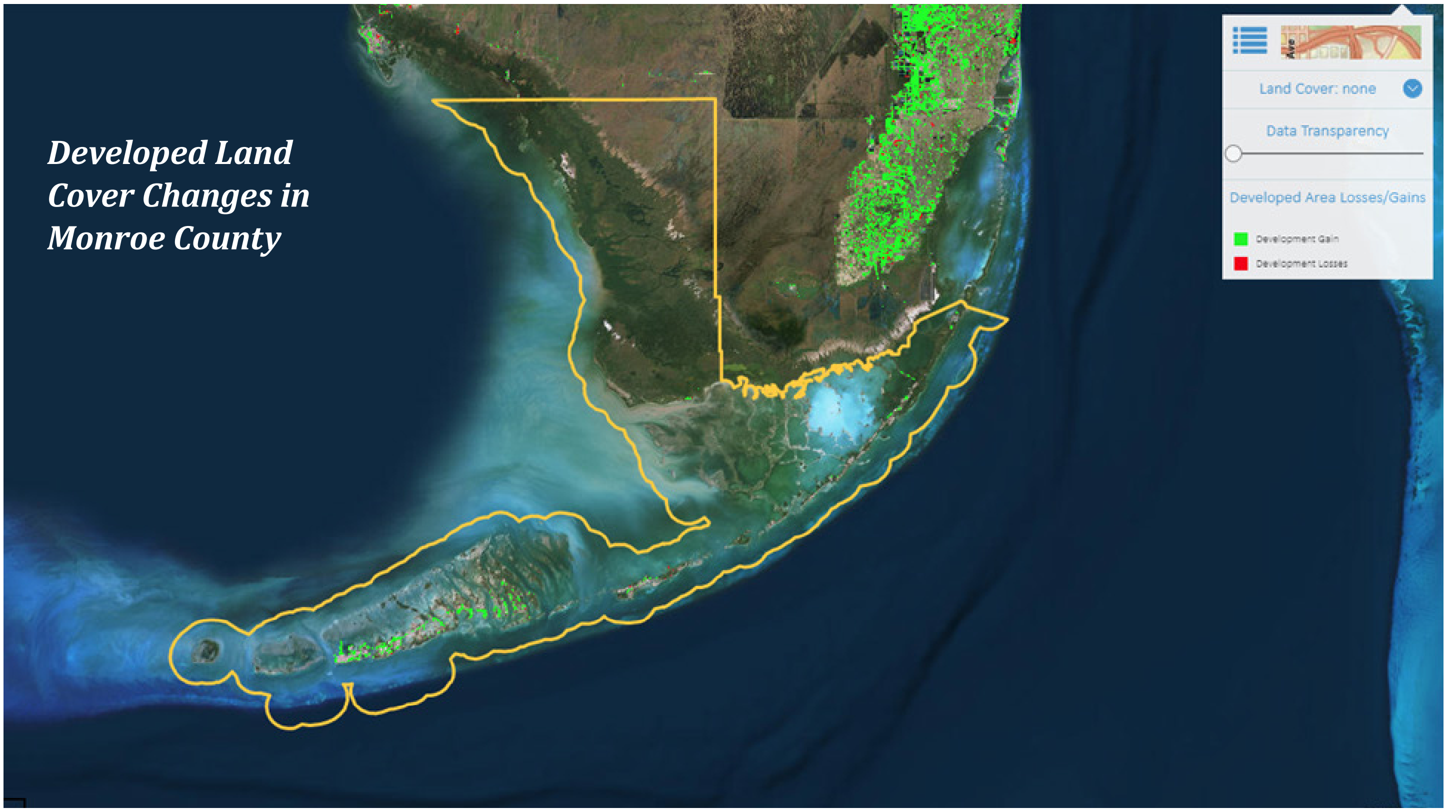



**Figure 24.** Developed land cover changes in Monroe County.

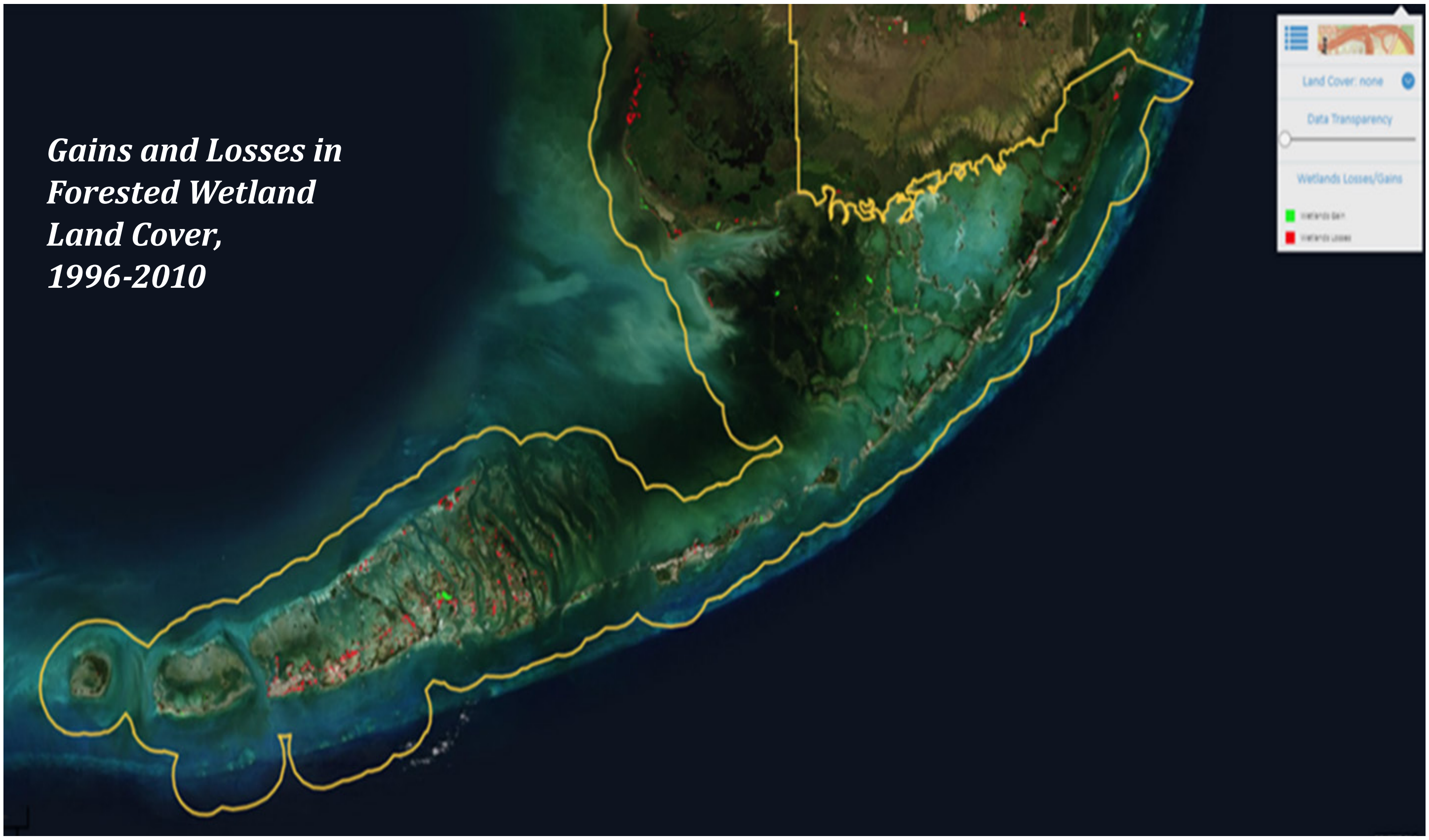



**Figure 25.** Gains and losses in forested wetland land cover, 1996-2010.

### *Distribution of Change (Losses and Gains) by Land Cover*

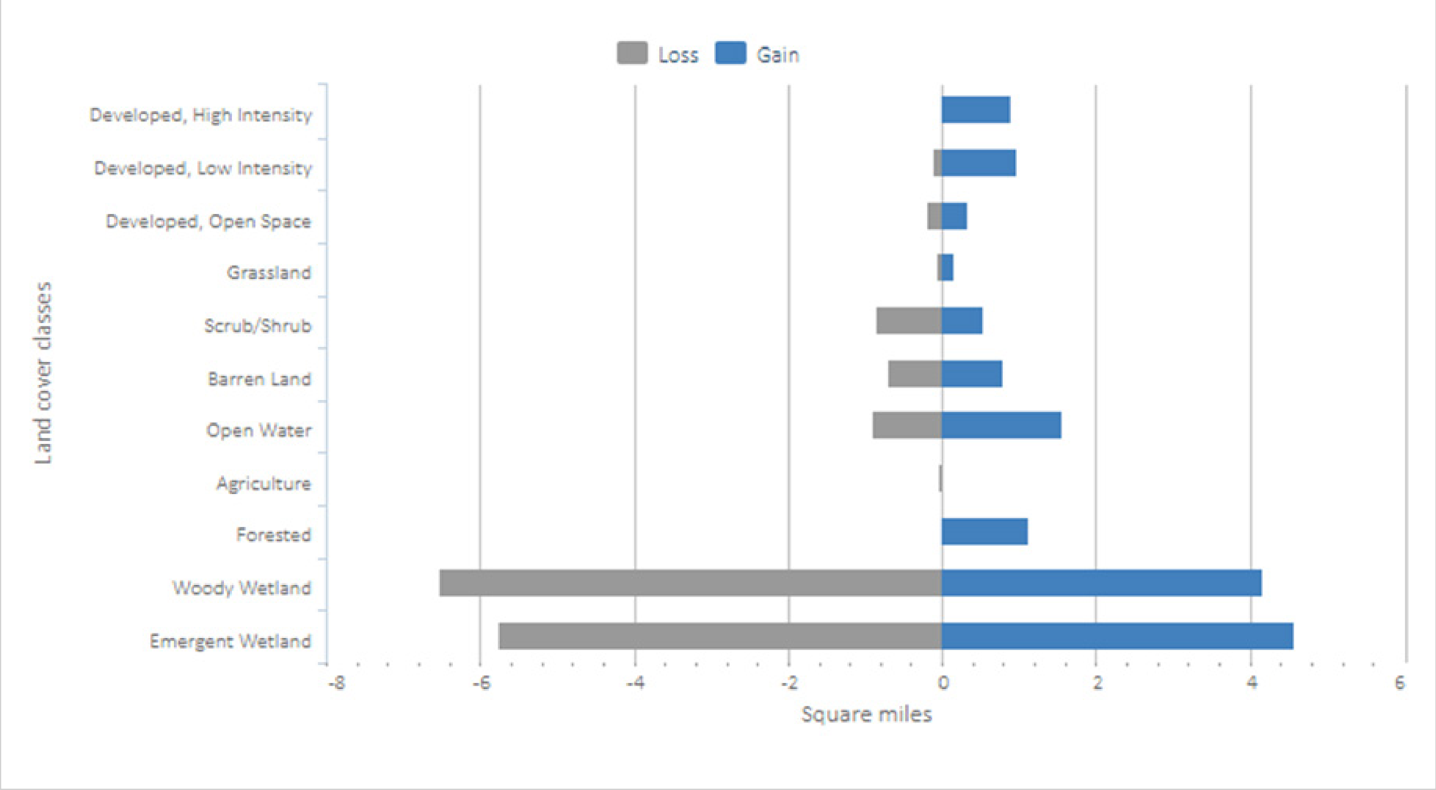



**Figure 26.** **Changes in land cover classes in Monroe County.**

### *Total Value of Economic Activity Protected by Florida Keys Coral Reefs (in 2010 dollars)*

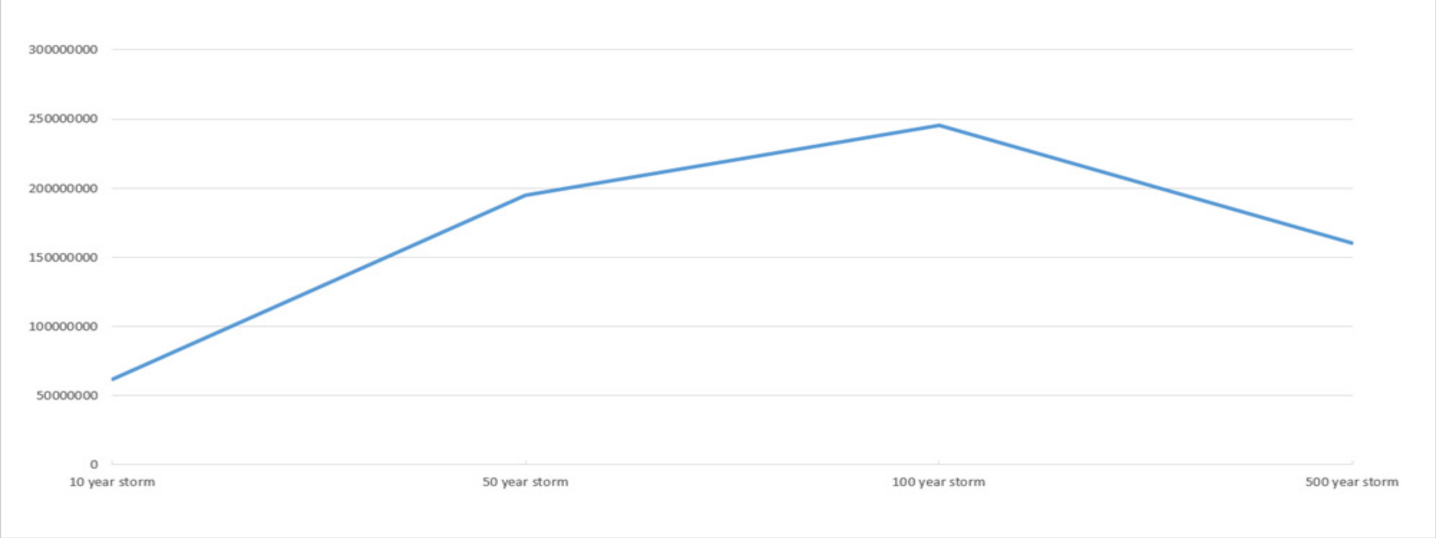



**Figure 27.** **Total value of economic activity protected by coral reefs in the Florida Keys.**

## Total Tourism Value

Tourism is the largest employer and sector of the workforce economy, with the tourism and hospitality industry employing approximately 31-44% (direct-indirect) of the workforce of Monroe County, or approximately 26,500 jobs (Key West Chamber of Commerce, 2019). In 2018, 65% of tourists listed viewing wildlife as a reason for their visit, 57% listed snorkeling as a reason for their visit, and 45% listed fishing as a reason for their visit. Thus, the total tourism value as calculated from the hospitality industry GDP was selected as an indicator for ecosystem services, as a benefit to the population of the Keys derived from nature. The last five years show a positive trend in total tourism value (Figure 28).

*Total Tourism Value from Hospitality GDP*

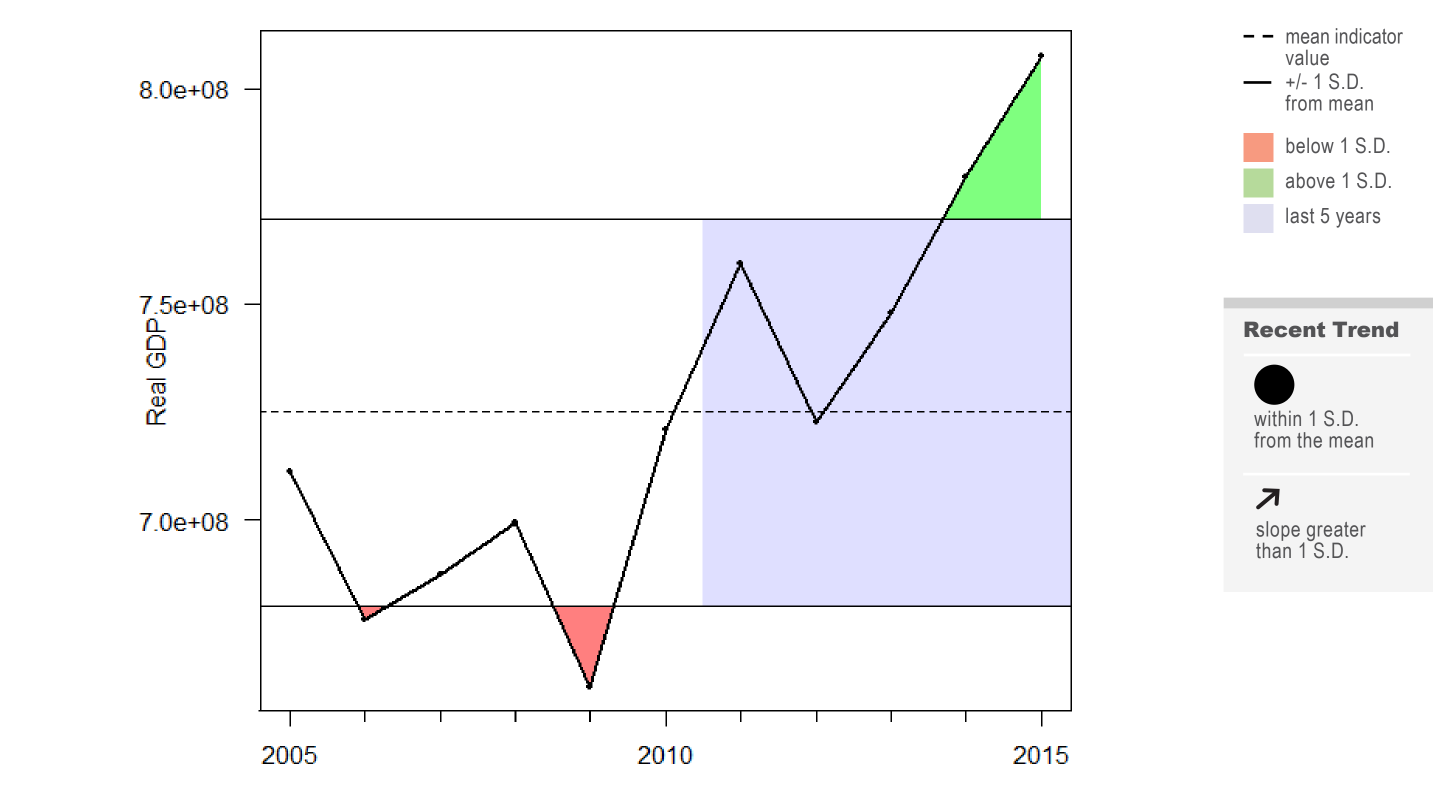



**Figure 28.** **Adjusted GDP from the Leisure and Hospitality Industry in Monroe County, NOAA Office for Coastal Management.**

**Florida beach. Photo: Debby Hudson on Unsplash**

## Housing Disruption in the Florida Keys: Gentrification Pressure and Social Vulnerability

Housing disruption was selected as an indicator of available ecosystem services, as a measure of social vulnerability in a vacation destination area with high amounts of second home ownership and low availability of rentable long term housing, both relating to high levels of tourism and gentrification. Additionally, housing disruption occurs due to hurricanes and storms. The Florida Keys have a high level of housing disruption in all regions/municipalities, except for northern Key Largo (Figure 29).

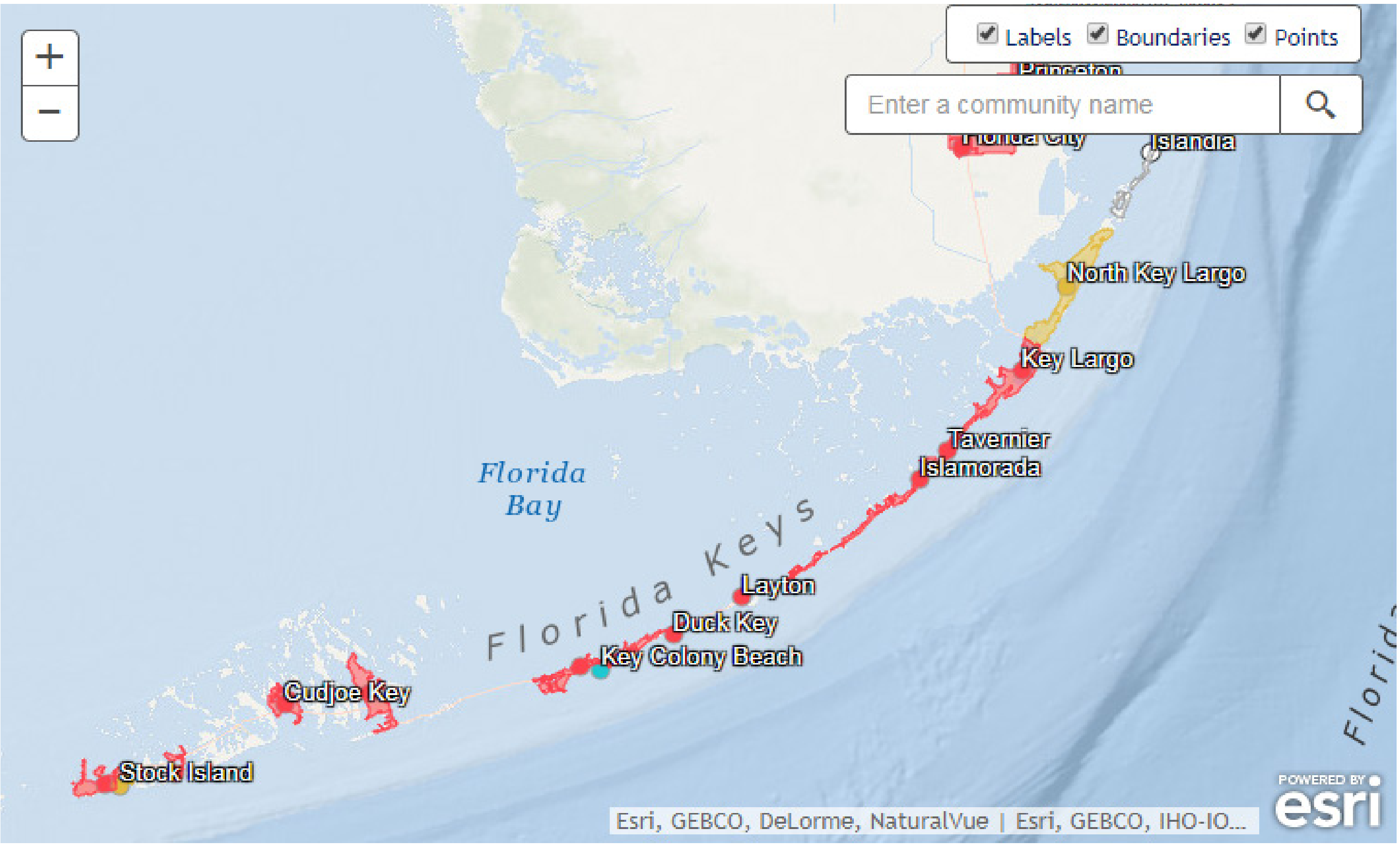
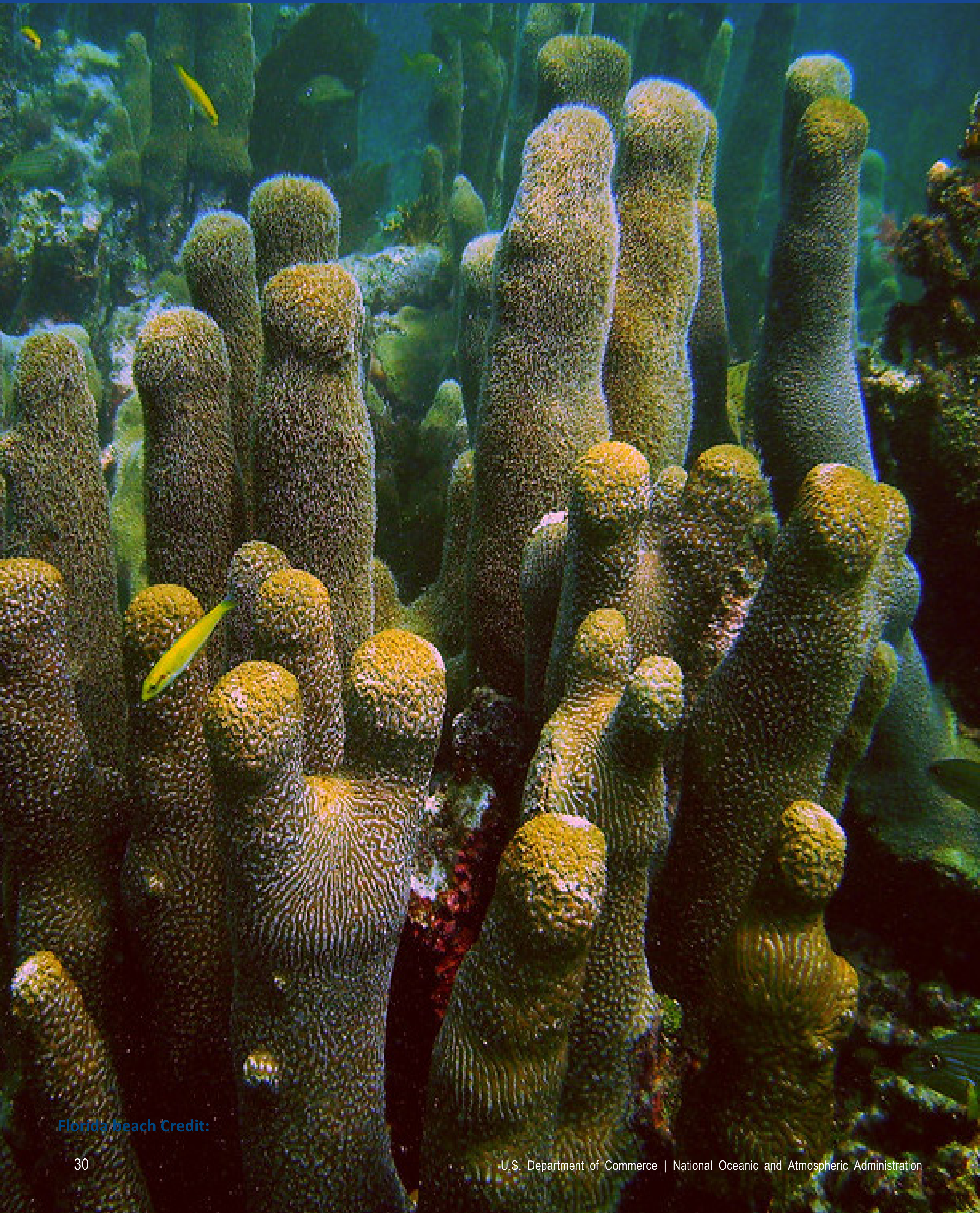



**Figure 29.** **Housing disruption: level of pressure from gentrification social vulnerability. Image: NOAA NCCOS**



Florida beach Credit:

# Habitat

## Coral Diversity

Coral diversity is considered to be a key factor in resilience, condition and ecosystem habitat function of coral reef ecosystems (McClanahan et al. 2012). Unfortunately, coral diversity as measured by coral species richness in the Florida Keys has dropped significantly below the mean since 2011. The species richness has remained stable in the last five years (Figure 30).

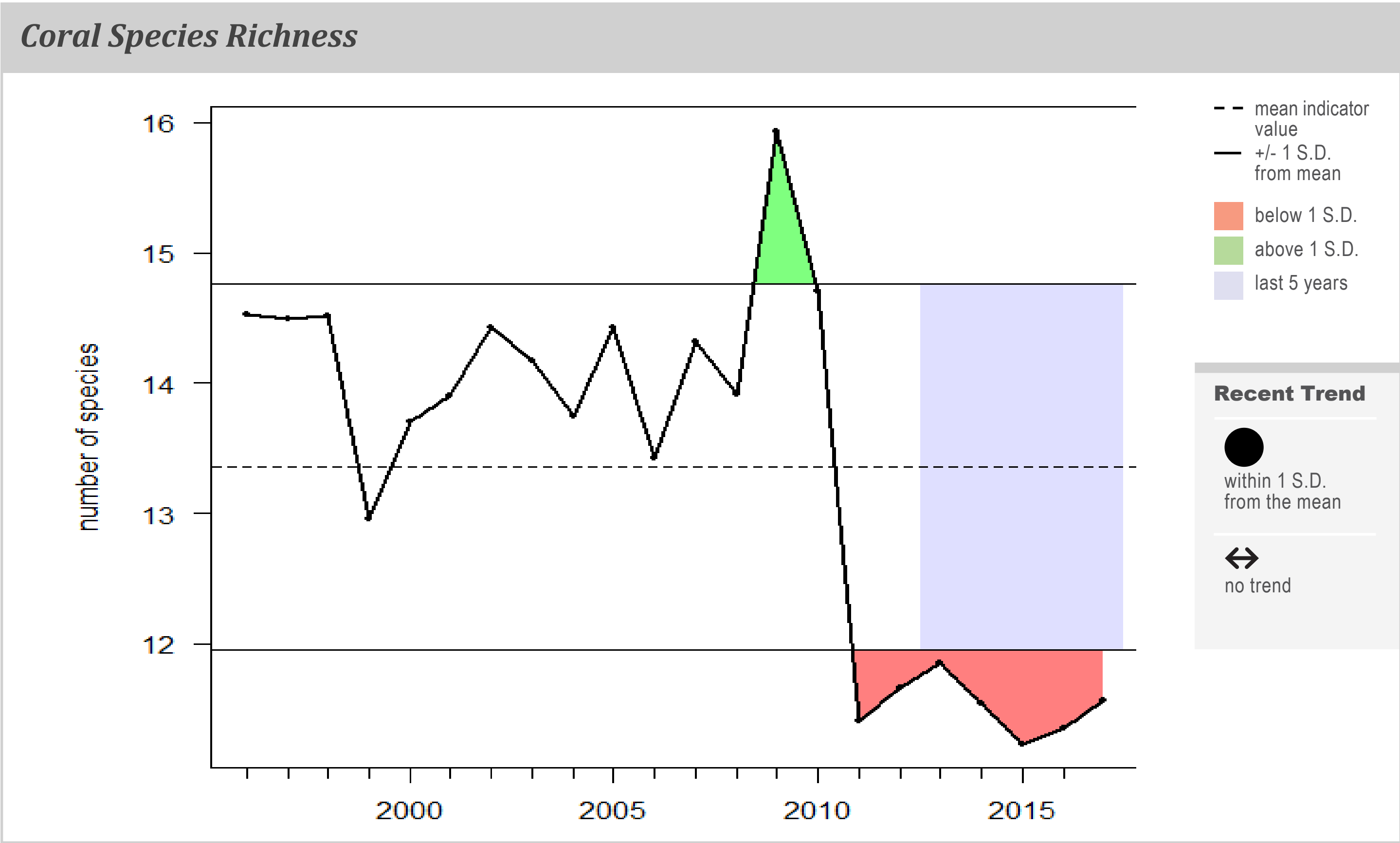



**Figure 30.** **Coral Species Richness in the Florida Keys.**

## Calcification and Carbonate Budget

Coral calcification as measured by carbonate budget and calcification rate per ecosystem calcifier at a study site in the Florida Keys has remained stable over the past five years (Figure 31).

***Carbonate Production***


**Figure 31. Total carbonate production at Cheeca Rocks study site, Florida Keys.**

***Calcification Rates per Coral Species/Type/Calcifying Algae, Cheeca Rocks, Florida, 2013-2016 (NOAA AOML ACCRETE lab)***

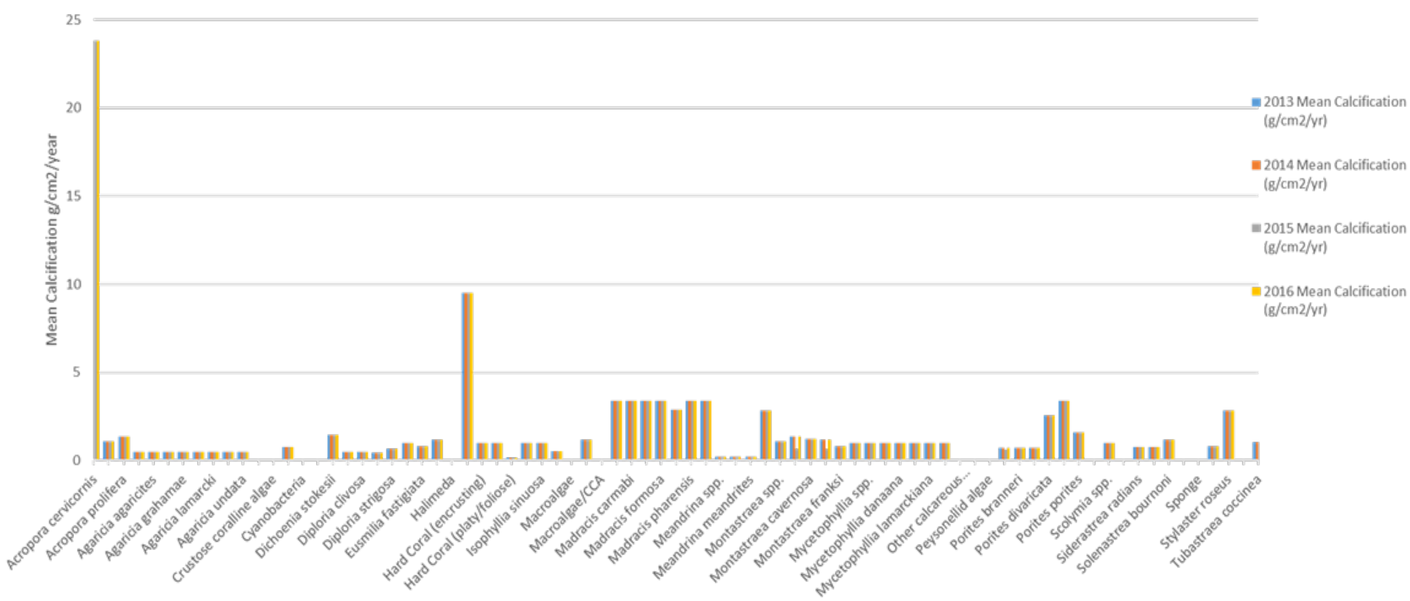



**Figure 32. Calcification rates per ecosystem calcifier, Cheeca Rocks study site, Florida Keys.**

## Coral Living Tissue Area

Coral calcification as measured by carbonate budget and calcification rate per ecosystem calcifier at a study site in the Average stony coral live tissue area is a clear indicator of the living and growing parts of corals left on the reef tract of the Florida Keys. This indicator has declined below the mean since 2014 with a significant downward trend (Figure33).

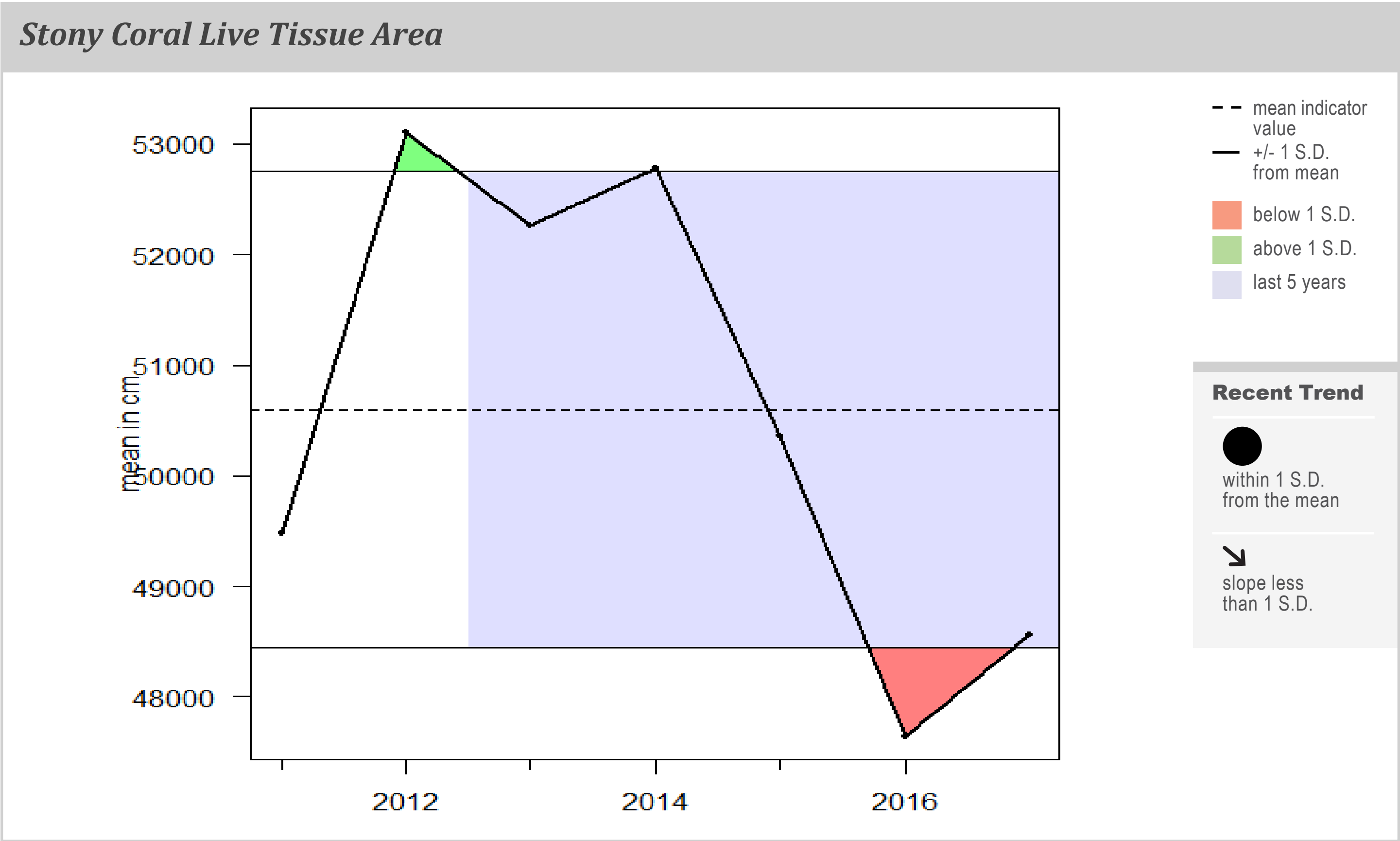



**Figure 33. Average stony coral live tissue area per CREMP surveys.**

## Living Stony Coral Colony Density

The mean density of living stony coral colonies in the Florida Keys indicates the population density as a measure of living coral prevalence and habitat provided as well as the population's ability to reproduce sexually as broadcast spawners. This density has remained stable over the past five years (Figure 34).

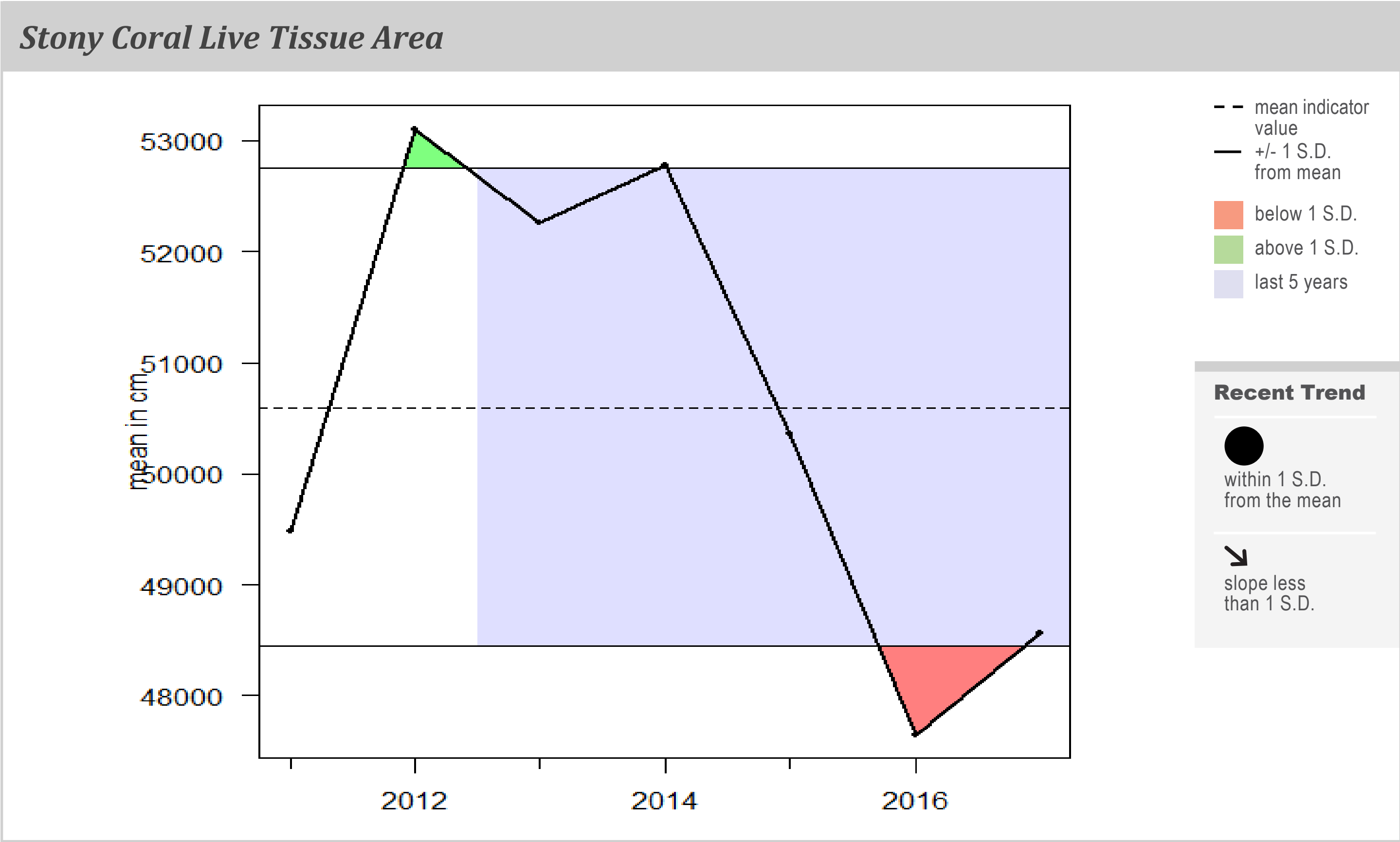



**Figure 34.** **Mean density of living stony coral colonies per CREMP surveys.**

## Spatial Cover of Mangroves

Not only do mangroves provide ecosystem services in the form of coastal protection, but are also an important nursery habitat for juvenile fish, invertebrate and other marine species, as well as important seabird roosting habitat. This habitat indicator has experienced a net loss in land cover over the past 20 years (FIgure 35).


**Figure 35.** **Wetland forest gains and losses in land cover, 1996 to 2010.**

## Seagrass Abundance

Seagrass meadows in nearshore areas of the Florida Keys provide juvenile marine species habitat, an important food source, and a key conduit for juveniles from nursery grounds in mangroves to the offshore coral reef tract. This habitat indicator, analyzed as total seagrass abundance, has declined more than one standard deviation below the mean in the last five years (Figure 36). When trends are plotted per species, there is a decline in all three most common species, but a more distinct decline in the abundance of Thallasia testudinium than in the other two species (Figure 37).

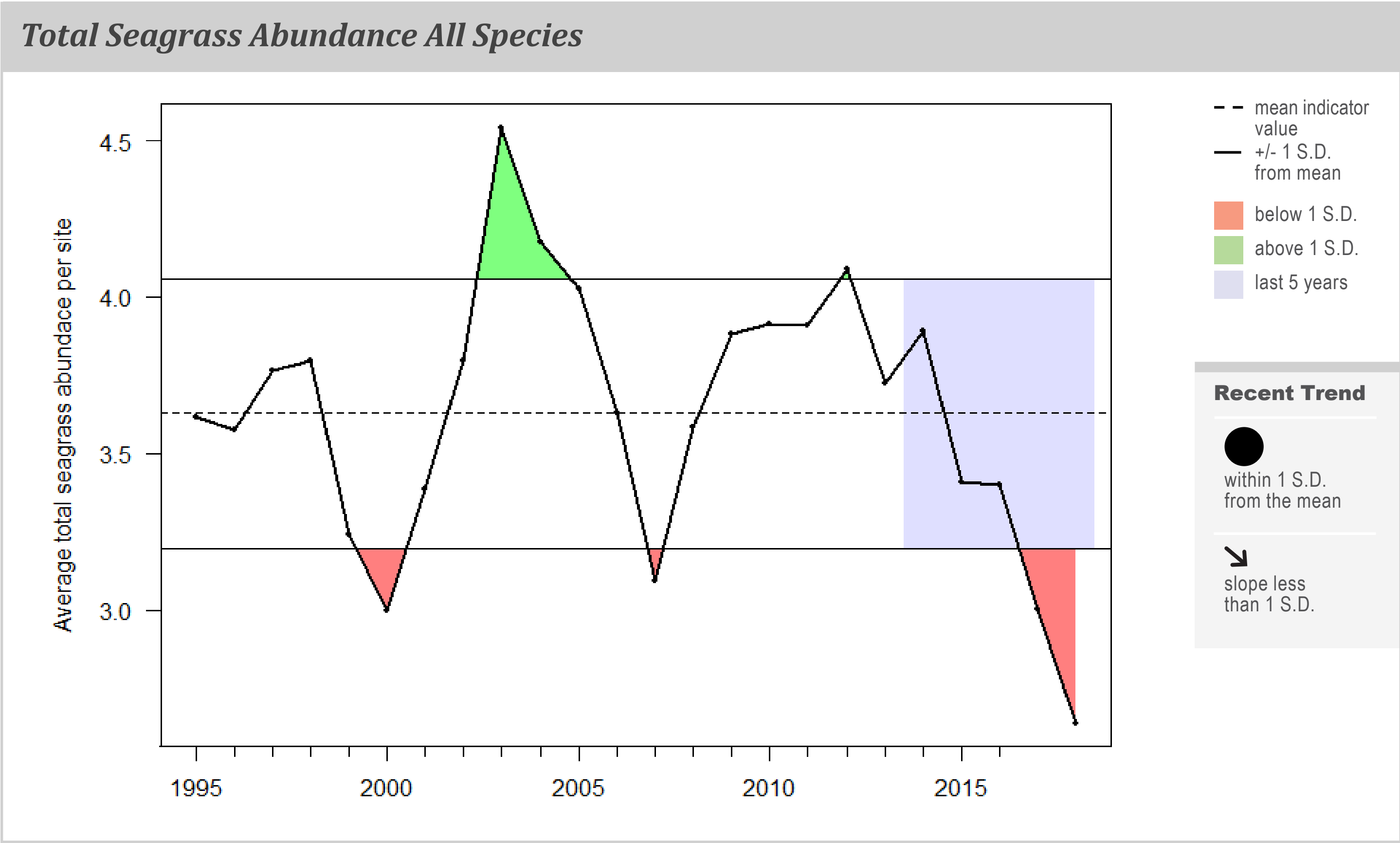



**Figure 36.** **Average total seagrass abundance per year, all species, per survey site.**

*Average Seagrass Abundance per Year per Species*

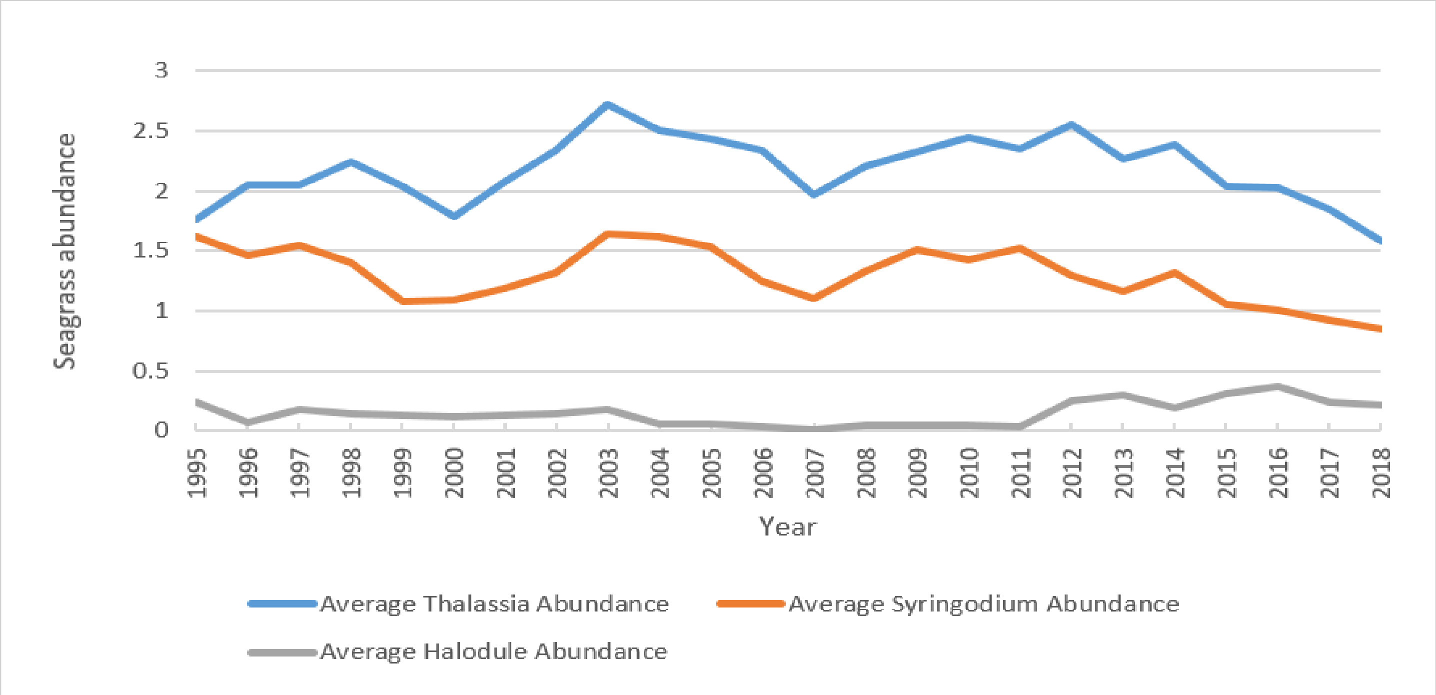



**Figure 37.** **Average total seagrass abundance per year, per species, per survey site.**

## Macroalgae Species Composition Abundance

Calcareous green macroalgae is a calcifier and contributes to the carbonate budget of reef ecosystems in a positive way. This is important in allowing coral reefs to accrete rather chemically dissolve. Total abundance of calcareous green macroalgae on Florida Keys reef sites has declined more than one standard deviation below the mean in the last five years (Figure 38).

*Calcareous Green Macroalgae Total Abundance*

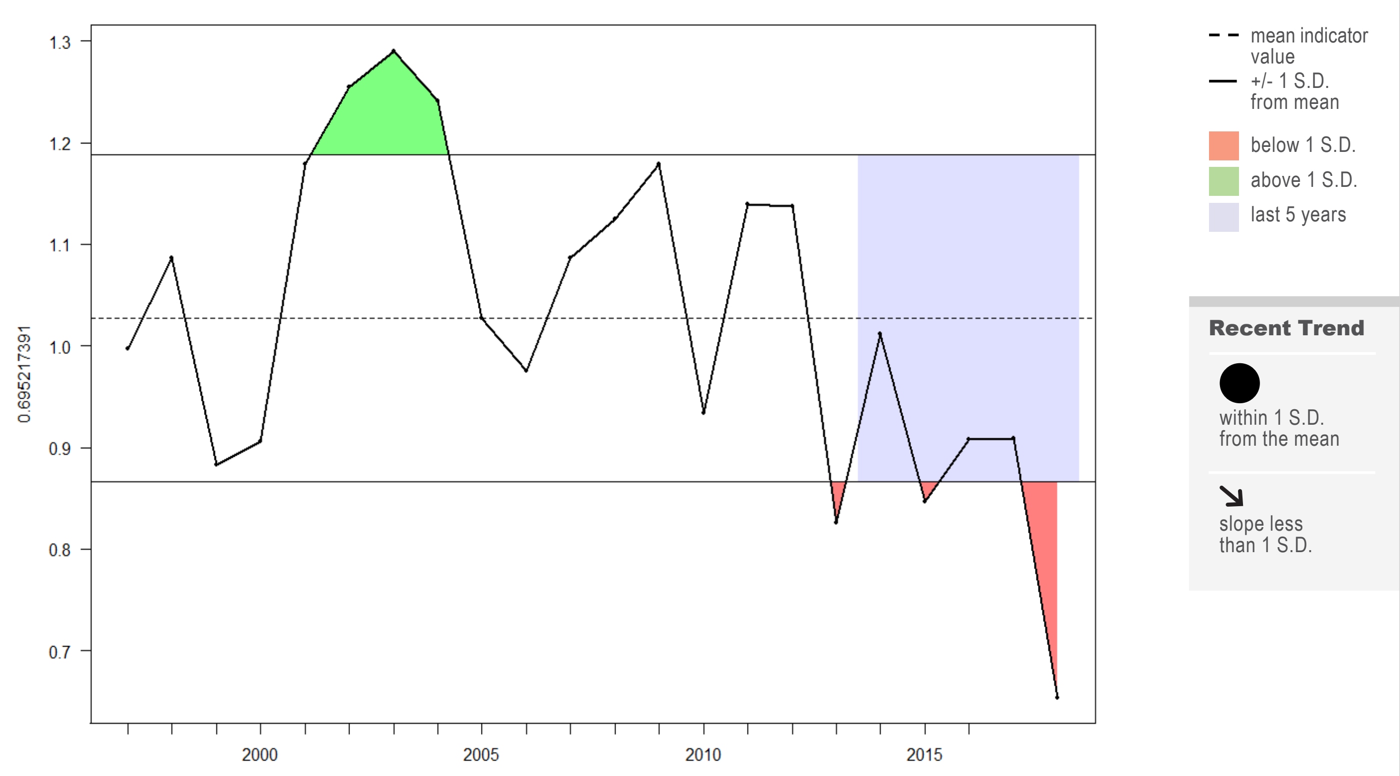



**Figure 38. Total abundance of all calcareous green macroalgae species, per Florida Keys survey sites.**

## Changes in Sponge and Gorgonian Abundance

Changes in sponge and gorgonian/octocoral (soft coral) density, volume and cover were chosen as an important indicator of habitat condition in the Florida Keys. While soft coral density per Florida Keys survey site increased more than one standard deviation above the mean in the past five years, volume and colony count of barrel (genus *Xesto*) sponges declined significantly since 2017 (Figure 38, 39, and 40). This could be the result of a number of disturbances: Hurricane Irma in September 2017, or the spread of disease on the reef tract in 2017-2018.

### *Mean Octocoral Density*

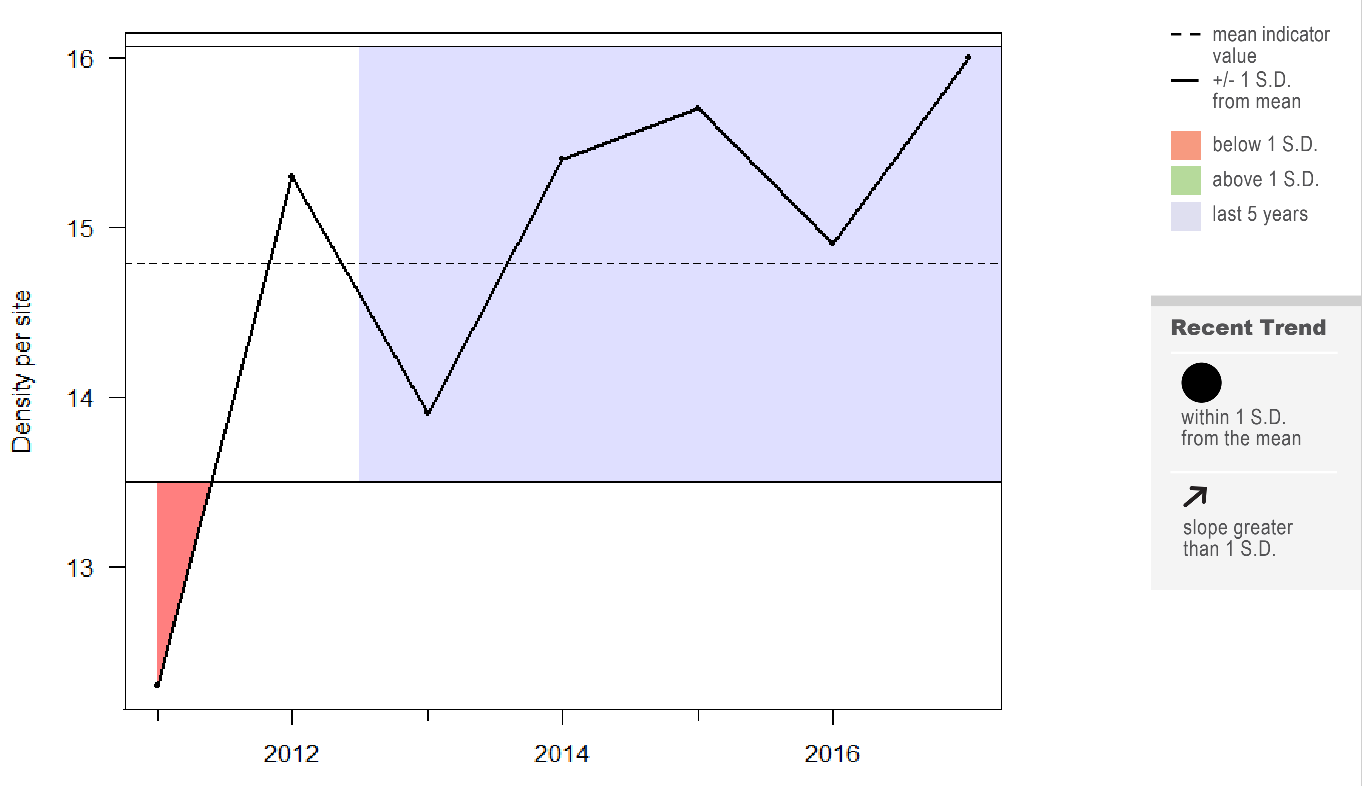



**Figure 39.** **Mean density of octocorals per survey site.**

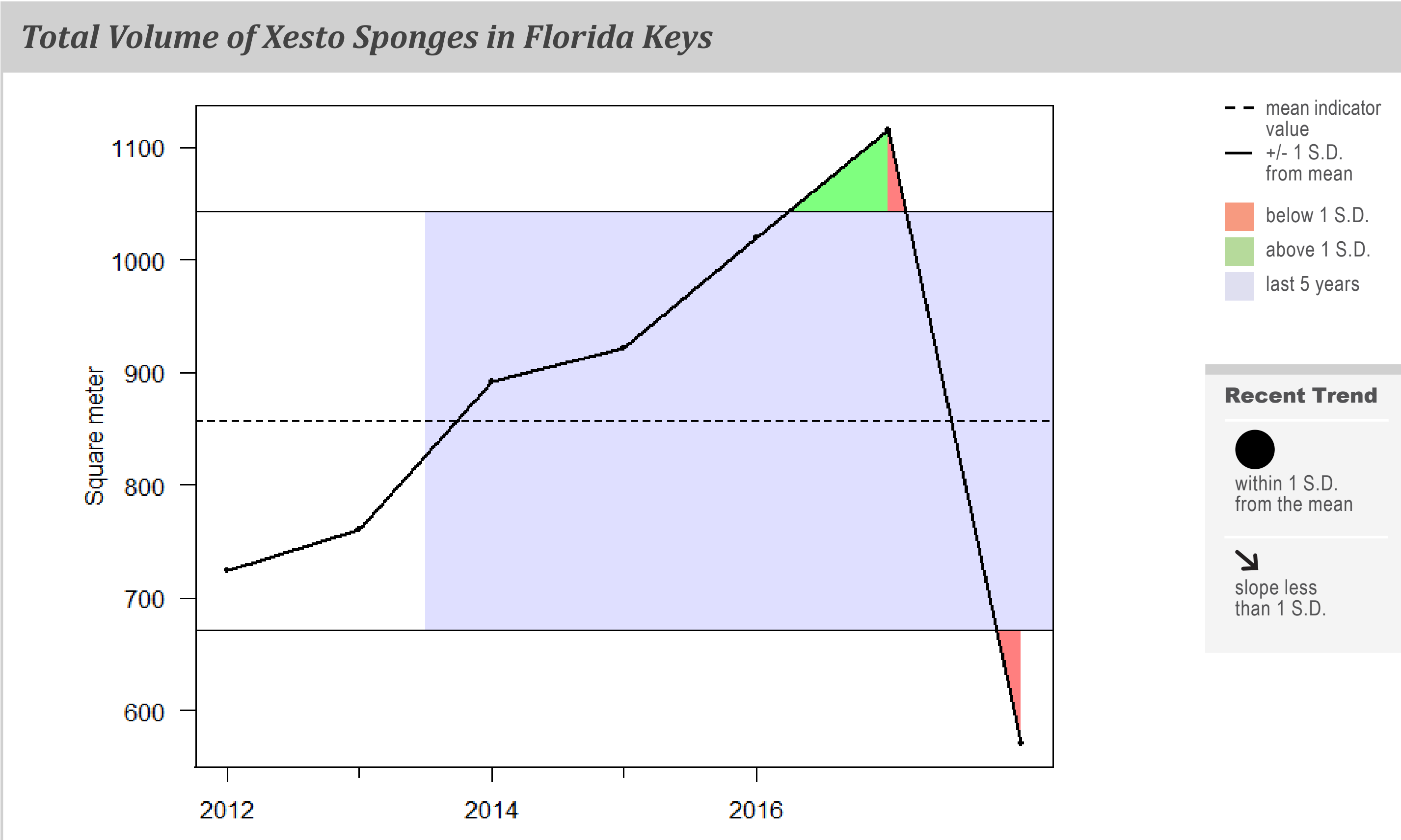



**Figure 40.** **Volume of Xestospongia muta in the Florida Keys.**

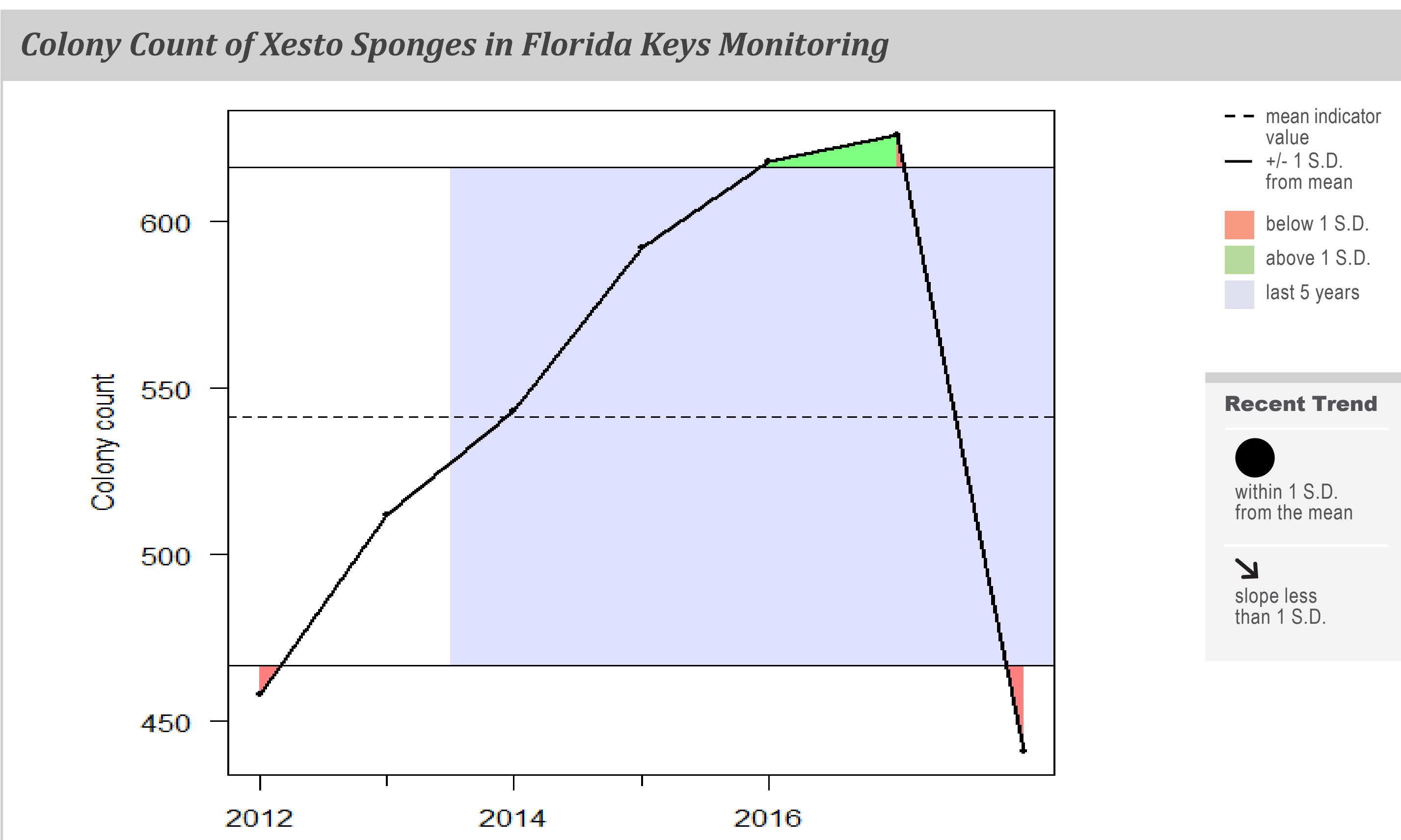



**Figure 41.** **Colony count of Xestospongia muta in the Florida Keys.**

# Key Species/Living Resources

## Biodiversity Index of Fish Species Presence and Abundance

The abundance and diversity of subtropical and tropical species and living resources seen in the waters of the Florida Keys is remarkable and unique, and the presence and assemblage of coral reef species were a main reason for sanctuary designation. Though biodiversity indices trends have waned overall, there was an increase seen in the last five years. The abundance of invasive lionfish has peaked, though trends over the past five years are stable and not increasing. Though discouraging recent trends of a decrease in the number of sites with endangered coral species present are seen, the status of percent coral cover of reef building species has remained stable over the past five years, as has the average abundance of identified key fish species, though both trends have been in decline overall.

*Simpson's Biodiversity Index of Fish Species*

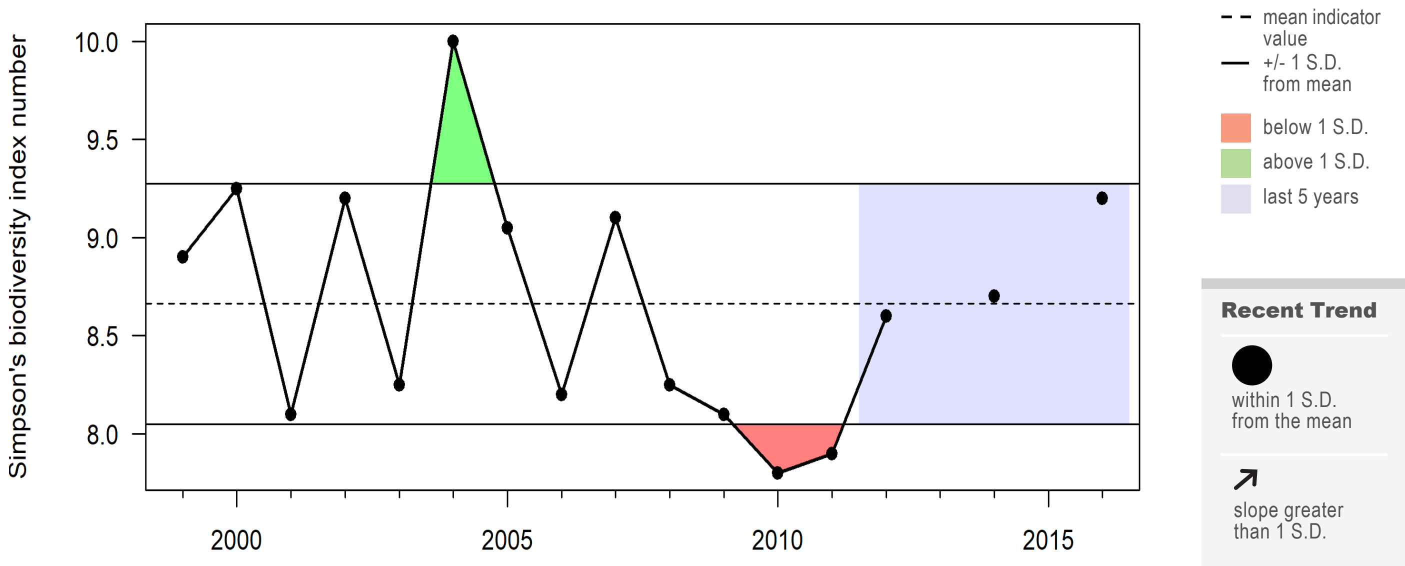
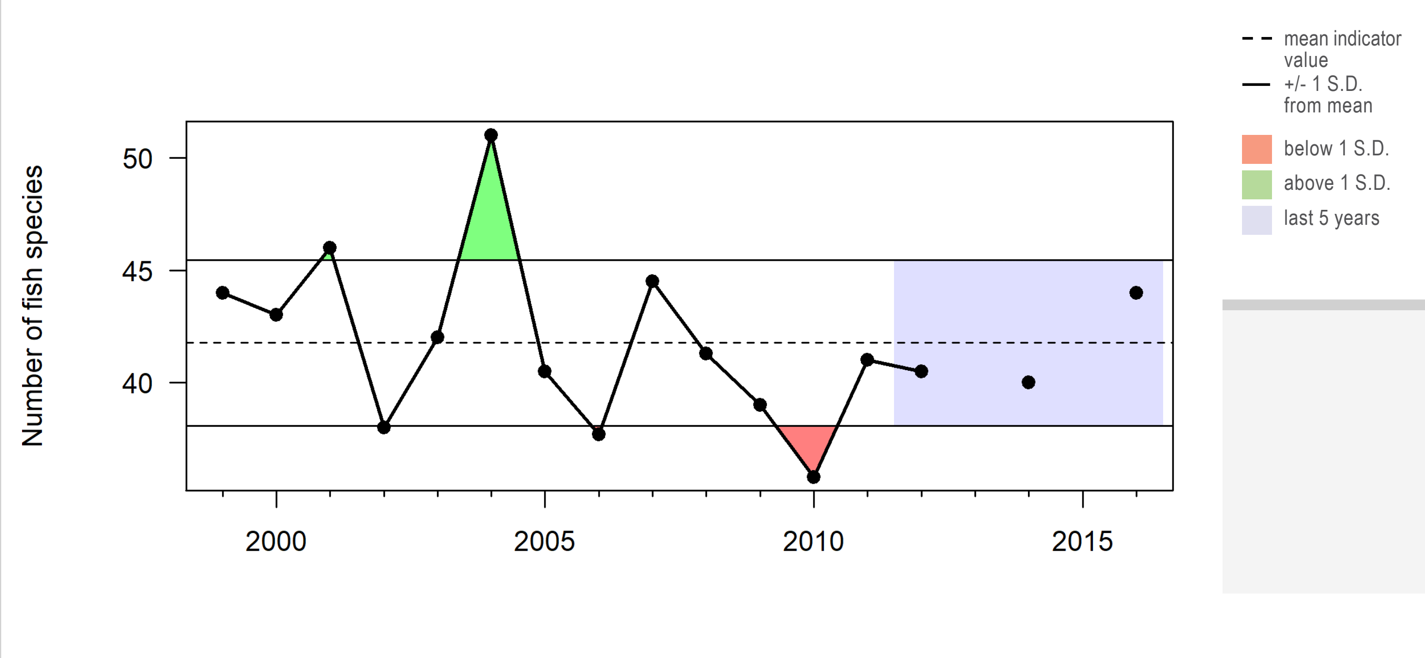



**Figure 42.** **Biodiversity of fish species in the Florida Keys per the Simpson's biodiversity index.**

### *Mean Effective Number of Fish Species*




## Lionfish Change in Presence and Abundance

Lionfish (*Pterois volitans*) are native to the Indo-Pacific, yet were released in the South Florida Atlantic region and have quickly become an invasive species. They have no natural predators in this region, and eat juvenile reef fish at a high rate. Therefore, it is of little surprise that their abundance per reef survey site in the Florida Keys has significantly increased above the mean since 2009, though trends for the past five years remain stable (Figure 43).

### *Average Abundance of Lionfish per RVC Site*

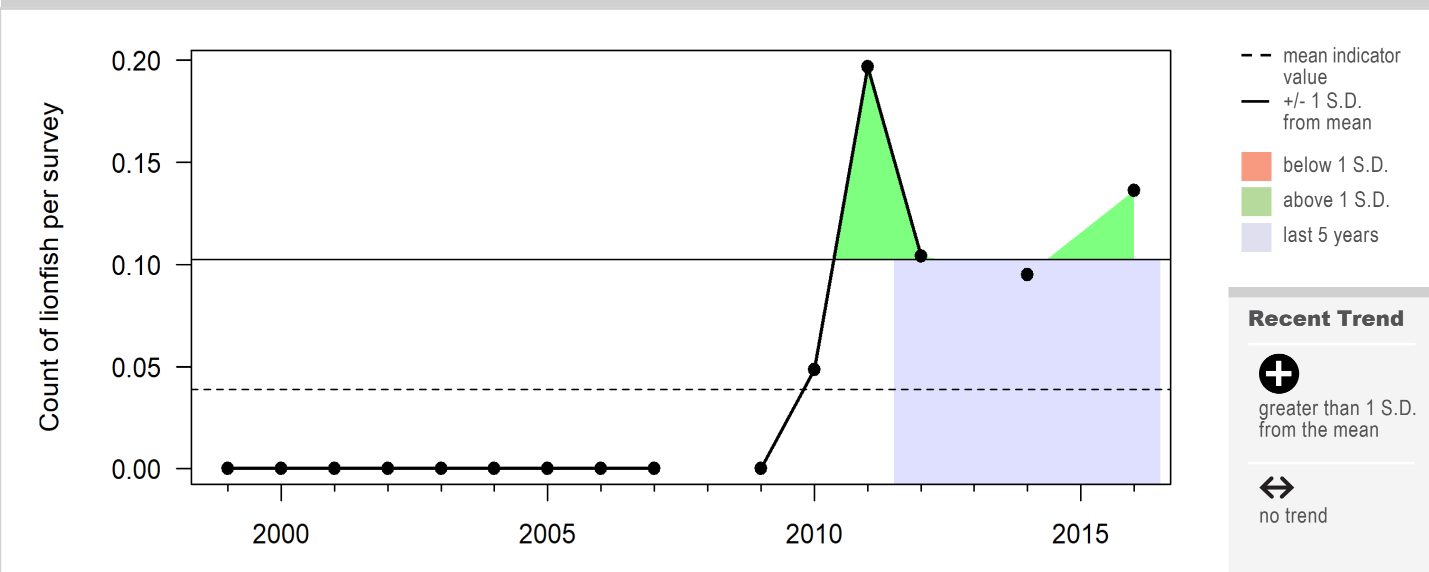



**Figure 44.** Average abundance of lionfish per survey in the Florida Keys.

## Endangered Species Act (ESA) Listed Corals Presence and Abundance

The protection and presence of hard coral species listed on the Endangered Species Act is of particular concern in South Florida; especially in the National Marine Sanctuary. These species, added to the listing in 2014, are: Staghorn (*Acropora cervicornis*), Elkhorn (*Acropora palmata*), Pillar (*Dendrogyra cylindrus*), Lobed Star (*Orbicella annularis*), Mountainous Star (*Orbicella faveolata*), Boulder Star (*Orbicella franksi*), and Rough Cactus (*Mycetophyllia ferox*). Thus, the presence of ESA listed corals was selected as an indicator. Unfortunately, presence as shown by the number of reef surveys that encountered ESA listed corals declined significantly over the last five years, though with high variability since 1995 (Figure 44).

***Endangered Species Listed Corals Present***

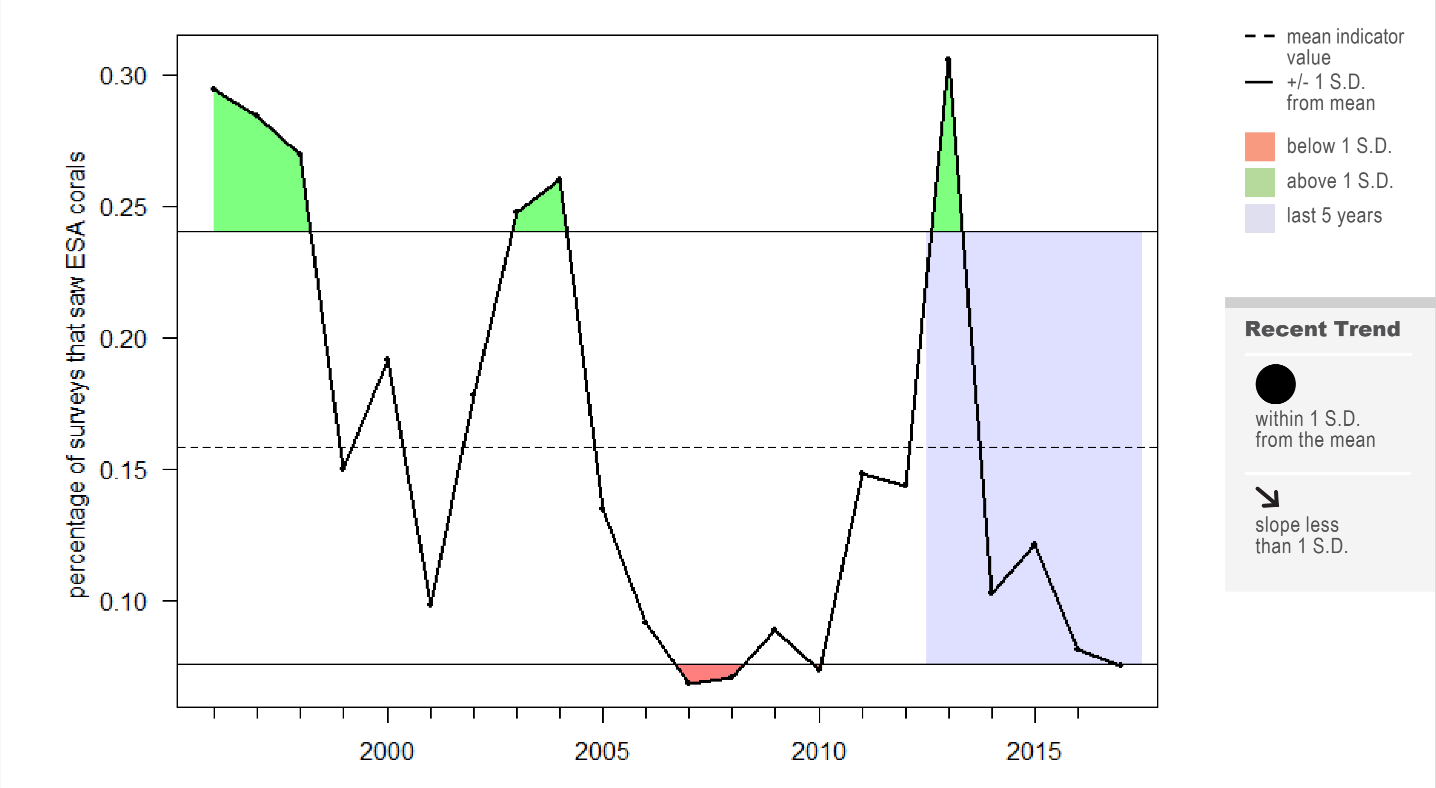



**Figure 45.** **Percentage of surveys that recorded Endangered Species Act listed corals present.**

## Coral Colony Counts

The density of stony coral colonies was selected as an indicator of living resources, as a measure of the amount of coral cover that considers whole colonies as well as population density. Stony coral colony density has remained stable over the past five years at Florida Keys reef monitoring sites (Figure 45).

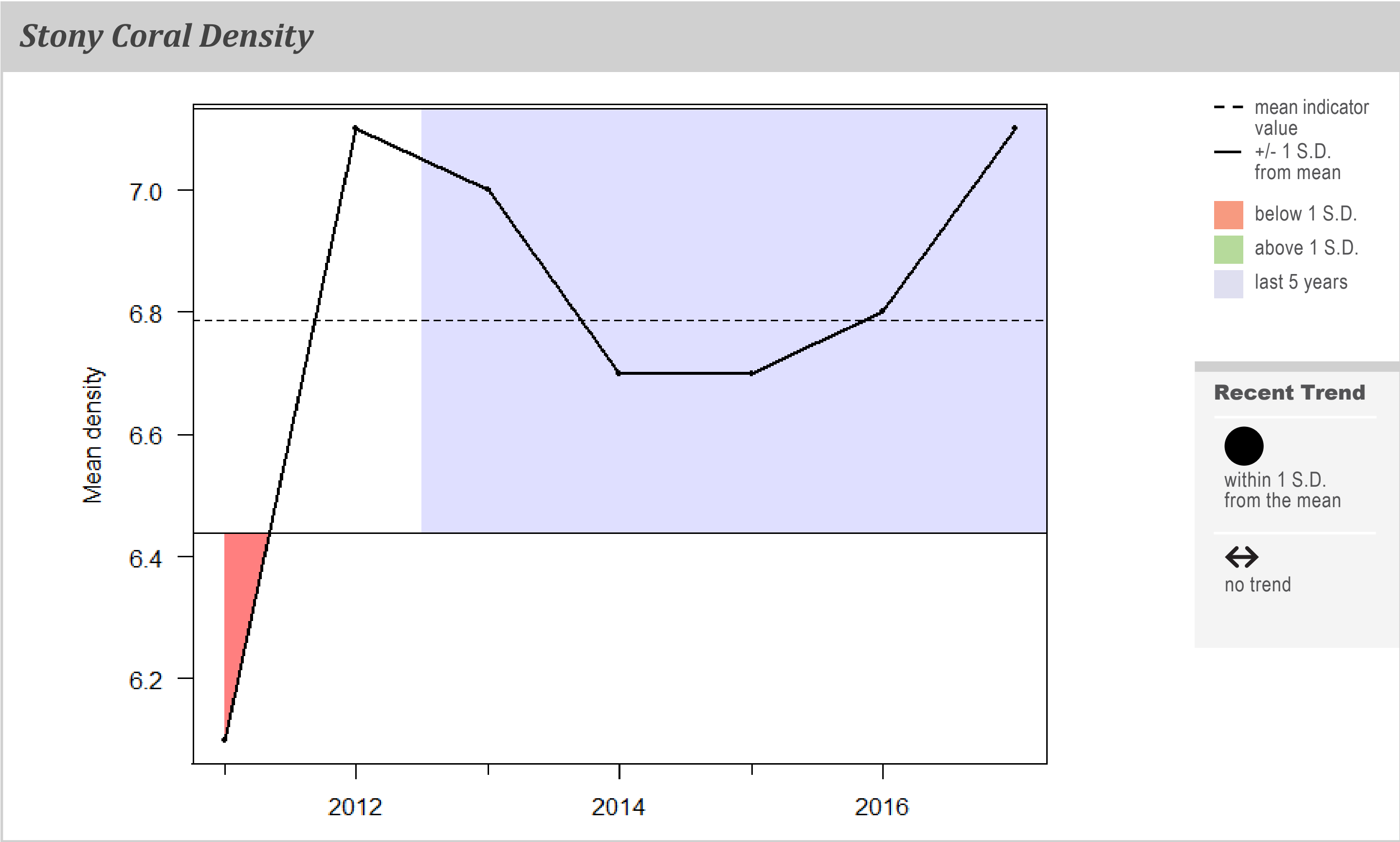



**Figure 46.** **Mean density of stony coral colonies in surveys in the Florida Keys.**

## Reef Building Corals Presence and Abundance

Presence and abundance of selected stony coral species that act as important reef builders was selected as a living resource indicator. These species are: *Acropora palmata*, *Acropora cervicornis*, *Meandrina meandrites*, *Diploria labrinthyformis*, *Montastrea cavernosa*, *Pseudodiploria strigosa*, *Pseudodiploria clivosa*, *Colpophylia natans*, and *Orbicella faveolata* for Florida Keys reefs. Abundance was represented by average coral cover per reef builder species (Figure 46), and presence was represented by the percentage of monitored reef sites with reef builder species present (Figure 47). These have remained surprisingly stable over the past five years, though there were declines in cover of *Orbicella faveolata* and *Montastrea cavernosa*, as well as a decline in the number of sites with *Colpophylia natans* present.

***Average Reef Builder Percent Coral Cover per in all CREMP Monitoring Sites, per Year***

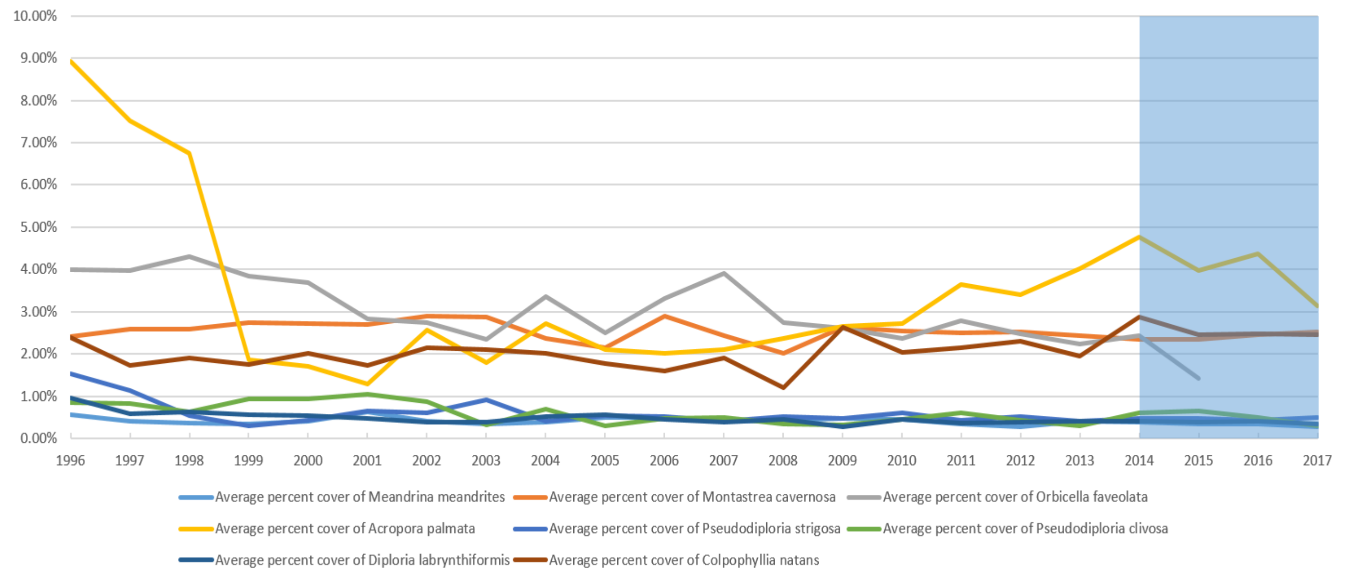



**Figure 47.** **Average percent coral cover of reef building stony coral species in all monitoring sites, 1996-2017.**

***Average Reef Builder Percent Coral Cover per in all CREMP Monitoring Sites, per Year***

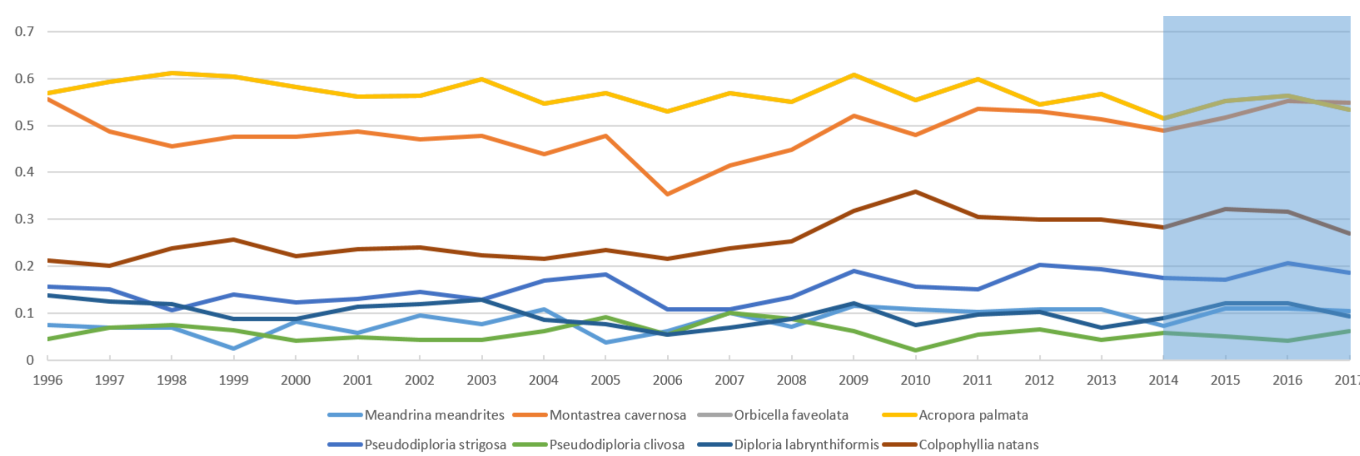



**Figure 48.** **Percentage of monitoring sites with reef building coral species present, 1996-2017.**

## Change in Abundance of Target Fish Species: Yellowtail Snapper, Hogfish, Red and Black Grouper

Four target fish species were selected as key indicators for the condition of living resources in the Florida Keys, due to their status as targeted species by recreational and commercial fishers (SEFSC, 2018). The status and trend in these four species were represented by calculating the average abundance per species per fishery independent dive survey, per reef site in the Florida Keys.

The abundance of both red (Figure 48) and black grouper (Figure 49) dropped from a site average above the mean to an average below the mean, from the early 2000s to 2014 and on, though the trend has remained stable over the past five years.

The abundance of yellowtail snapper has also dropped from a site average above the mean in the early 2000s to an average below the mean from 2009 on (Figure 50). Similarly, the trend has remained stable over the past five years.

However, the abundance of hogfish has recovered to a site average above the mean since 2013, and the trend is increasing over the past five years. This may be due to stricter bag and season regulations on recreational fishers in Atlantic waters.

*Average Abundance of Red Grouper per Survey*

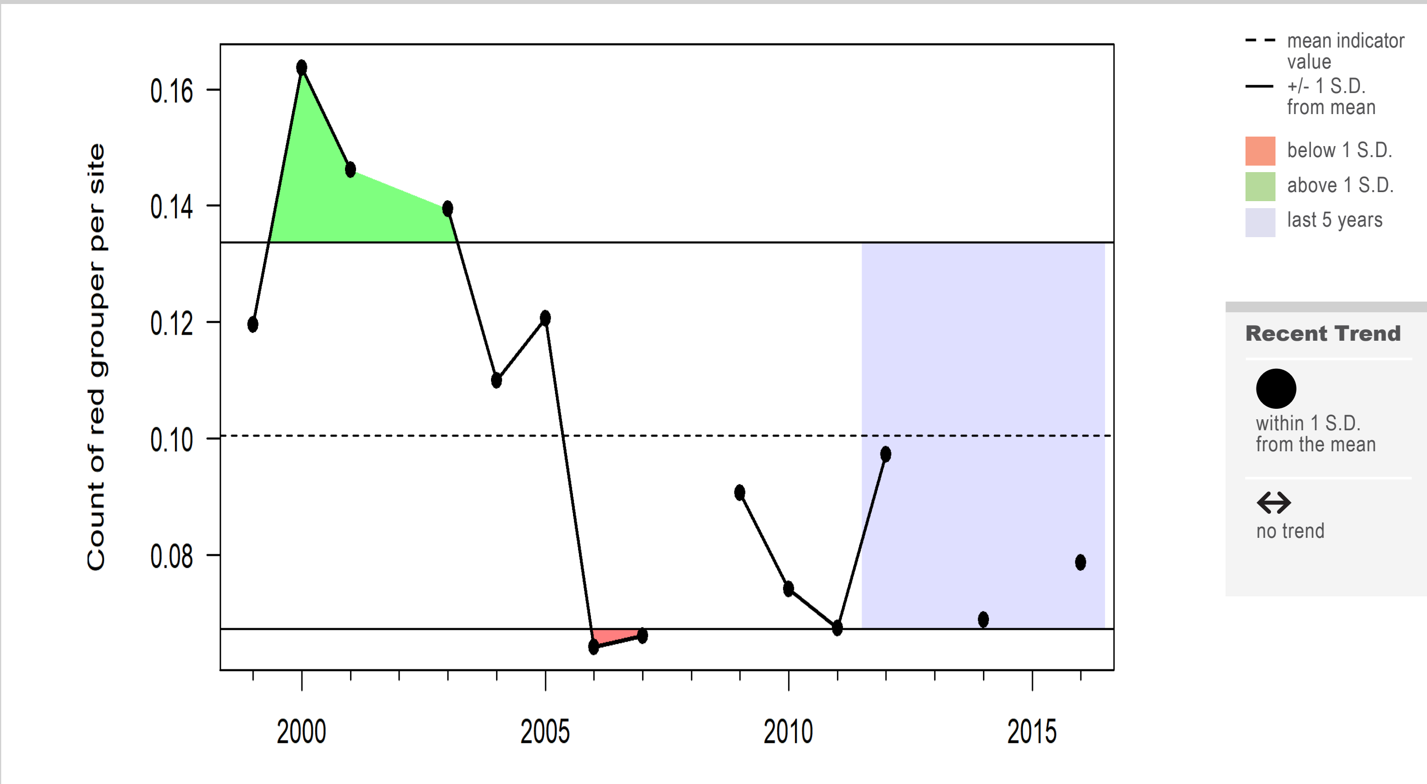



**Figure 49.** **Average abundance of red grouper recorded per site in the Florida Keys.**

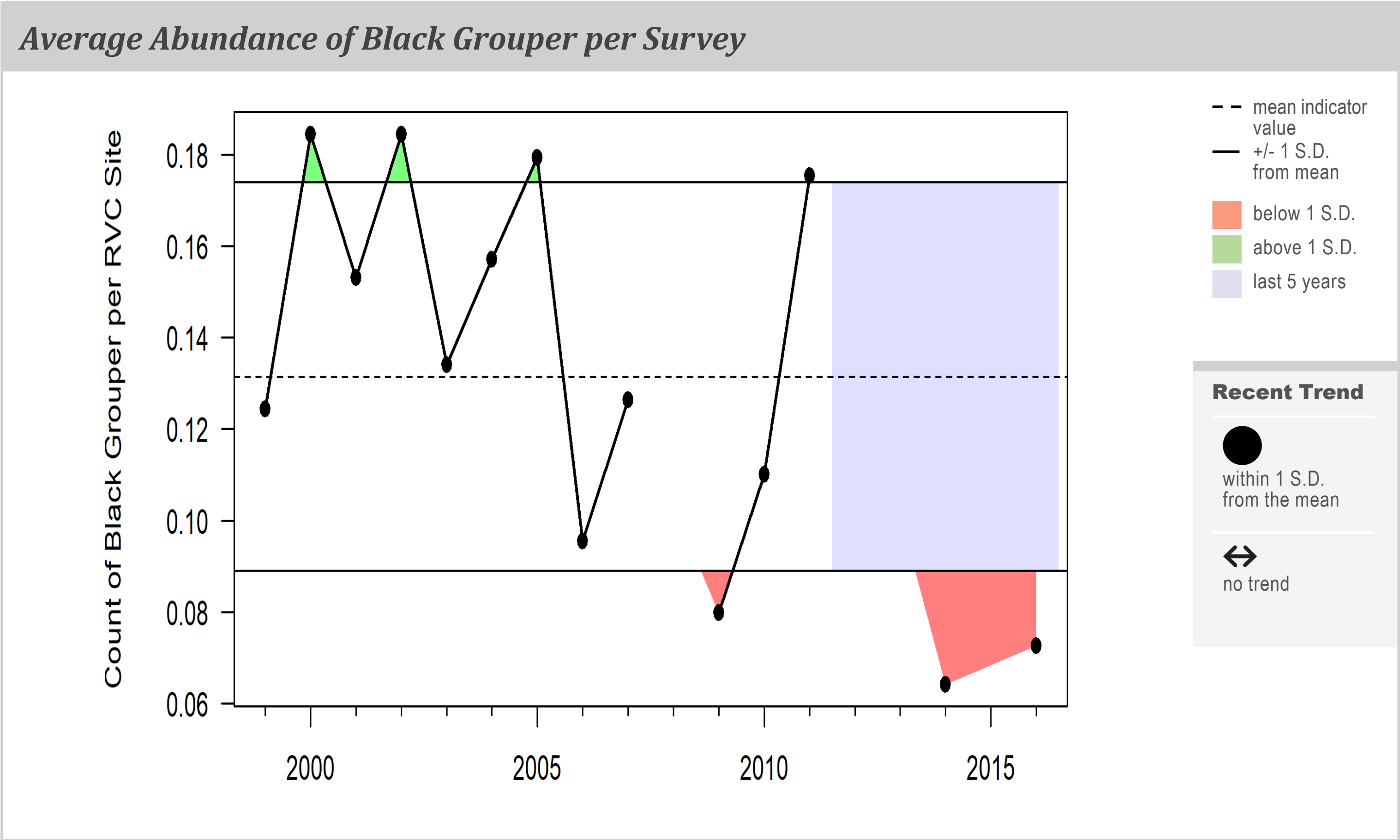



**Figure 50.** Average abundance of black grouper recorded per site in the Florida Keys.

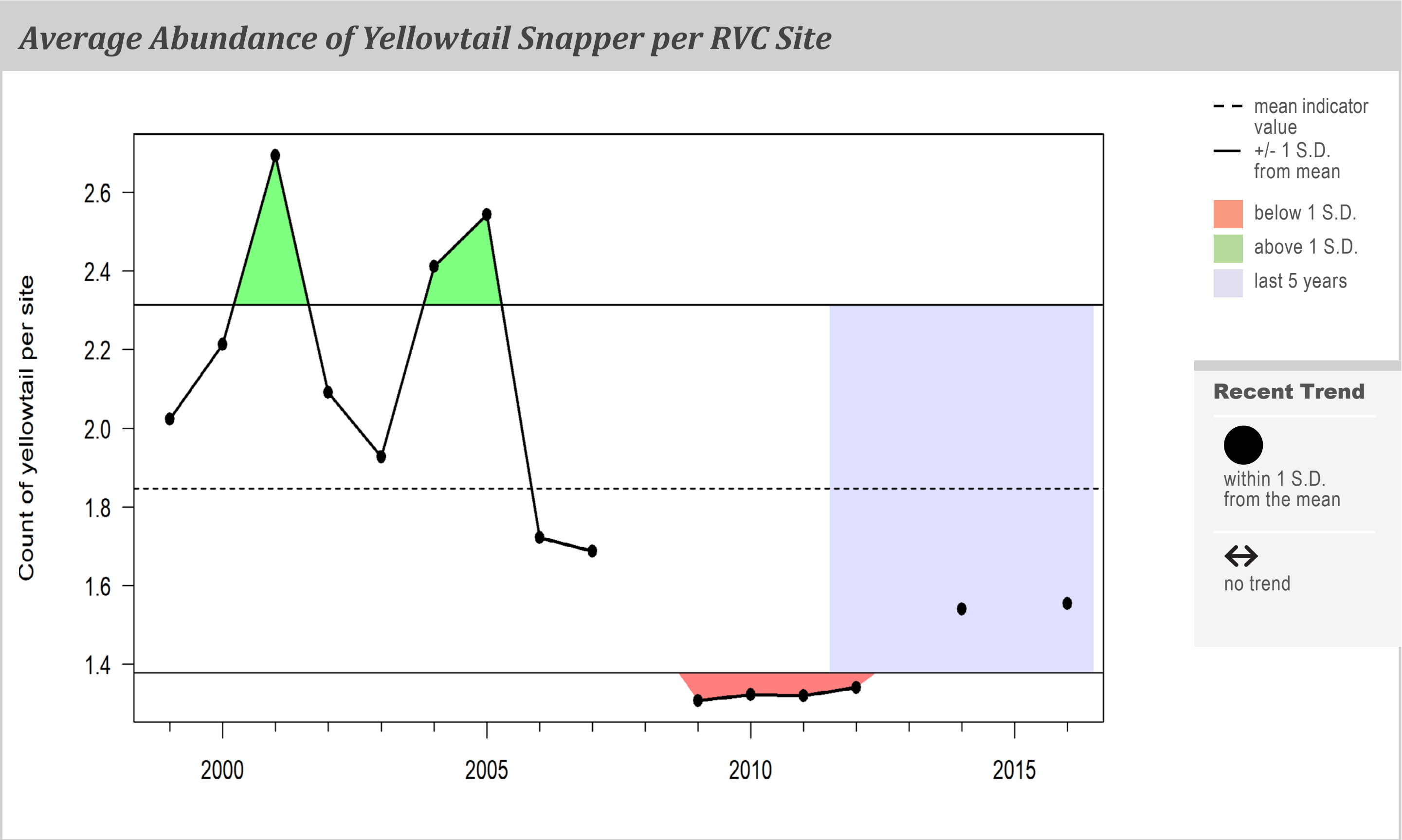



**Figure 51.** Average abundance of yellowtail snapper recorded per site in the Florida Keys.

### *Average Abundance of Hogfish per RVC Survey*

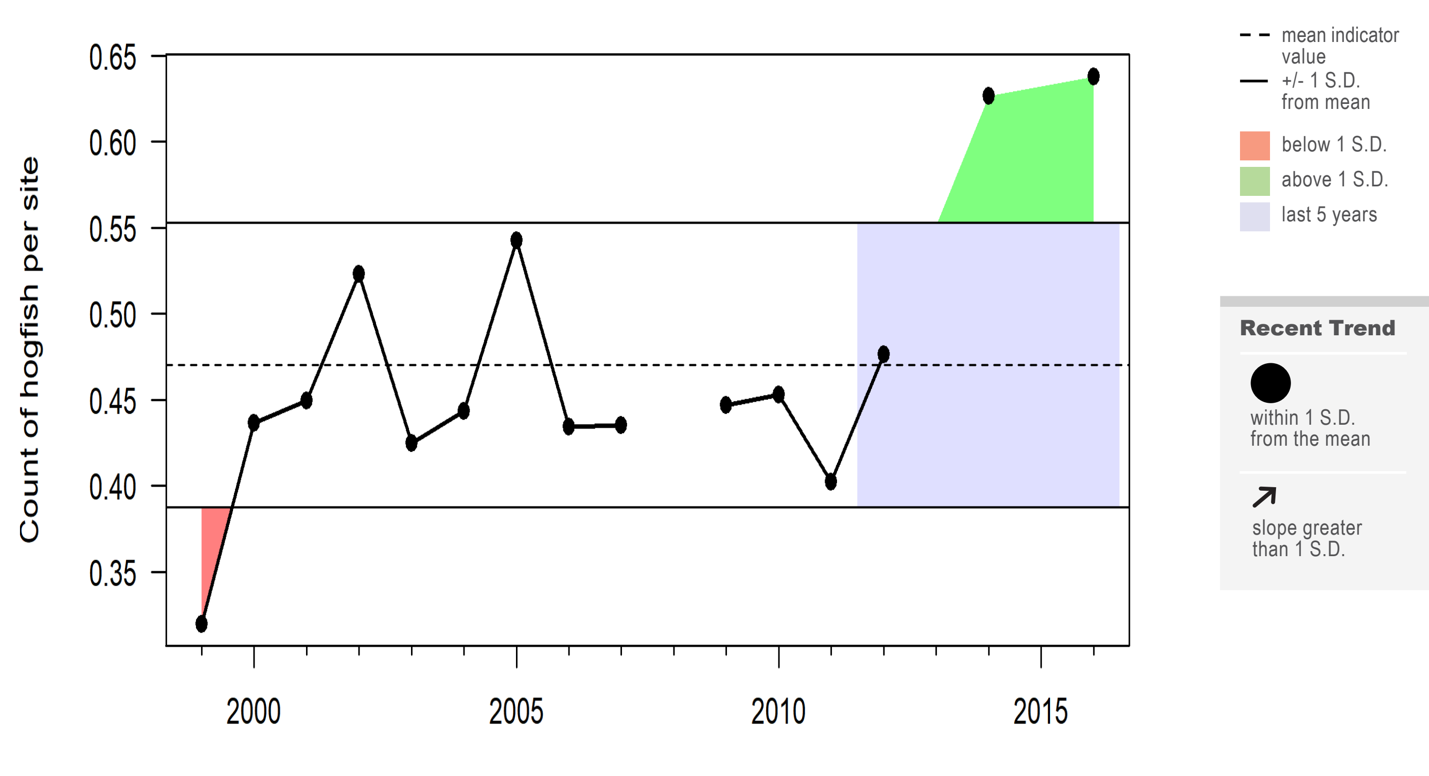



**Figure 52.** Average abundance of hogfish recorded per site in the Florida Keys.

# Sanctuary Water Quality

The following indicators were used to assess the status and trends in condition of water quality in Florida Keys National Marine Sanctuary: Dissolved inorganic nitrates, dissolved inorganic phosphates, dissolved oxygen, chlorophyll a levels on the reef tract and phytoplankton algal blooms, fecal indicators on sanctuary shorelines, and sea surface temperature change, Additionally, carbonate budget of sanctuary waters was also assessed in the Habitat section due to its inherent connection with coral growth and accretion. These indicators were selected in an effort to relate to questions asked of all National Marine Sanctuaries in order to assess trends in water quality relating to eutrophication, public health, climate drivers of change, and factors in abiotic and biotic stressors. Eutrophication is the accelerated production of organic matter, particularly algae, usually caused by an increase in the amount of nutrients (primarily nitrogen and phosphorus) in surface waters (Stellwagen Bank National Marine Sanctuary Condition Report 2020). Public health concerns relate to water, beach, and/or seafood contamination (bacteria or chemical), while climate drivers relate to changes in temperature, ocean acidification, and climate patterns. Biotic and abiotic stressors include point and non-point contaminants and other factors such as disease.

## Dissolved Inorganic Nitrates

Dissolved inorganic nitrates, or DIN, can contribute to eutrophication in coastal subtropical oligotrophic waters. Worldwide, 90% of coral reefs exist in waters with less than 0.60 umols/L nitrate concentration (Kleypas, McManus and Menez, 1999). This indicator has been measured for more than 20 years at reef sites along the Florida Keys. Generally, this indicator has varied per year, but has experienced two spikes, in 2009 and 2015. There was been a declining trend in the past five years, though this may be an artifact of the spike in 2015 (Figure 52).

### *Dissolved Inorganic Nitrates*

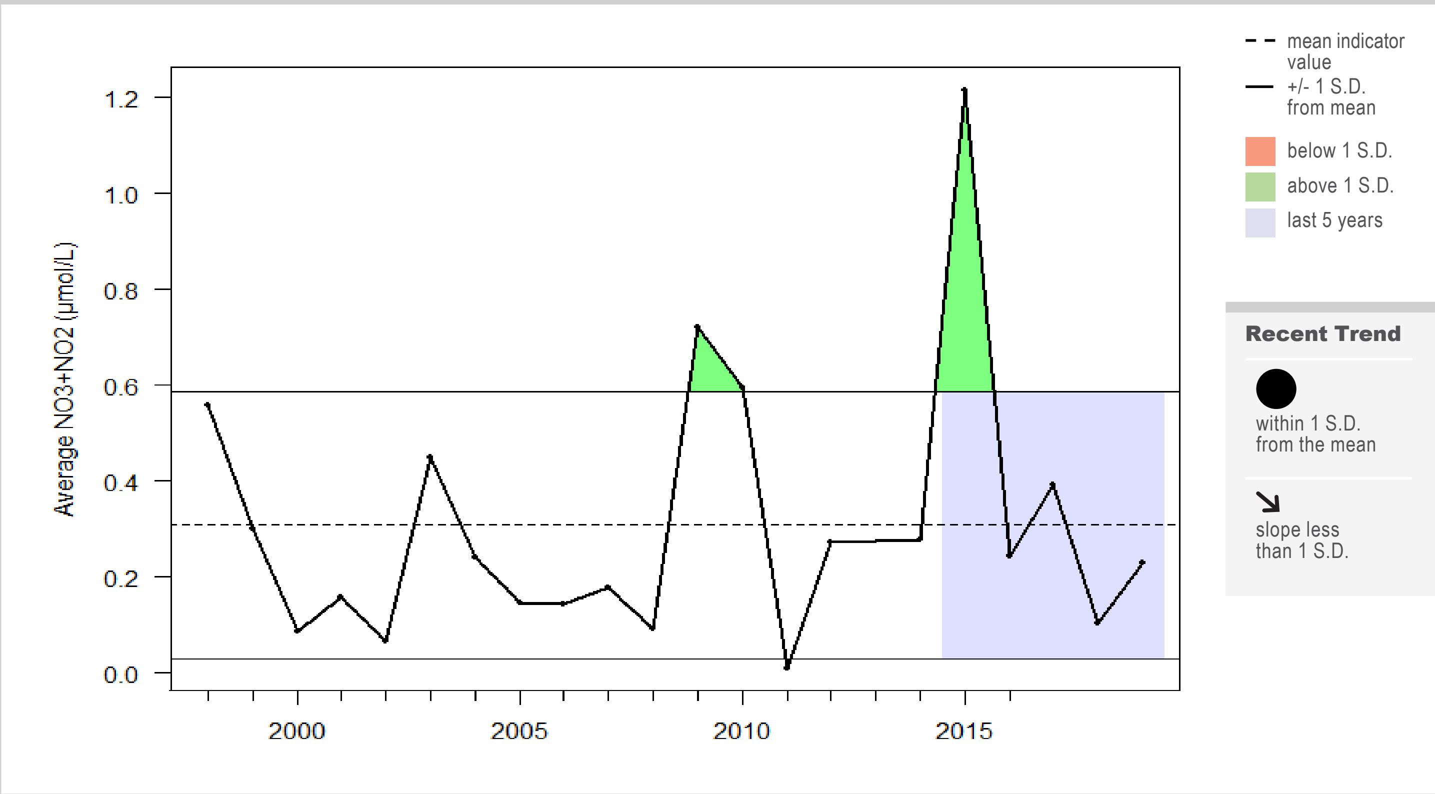



**Figure 53.** **Average level of nitrate nutrient suite for all Florida Keys stations per year.**

## Dissolved Oxygen

Dissolved oxygen is an important component of ecosystems both in terms of biotic demand, decomposition demand as well as biotic primary production. This is an indicator also affected by change in water temperature. Dissolved oxygen measured at regular intervals on Florida Keys reef sites has varied over the past five years but not shown a distinct upward or downward trend (Figure 53).

*Dissolved Oxygen from All Florida Keys Reef Sites*

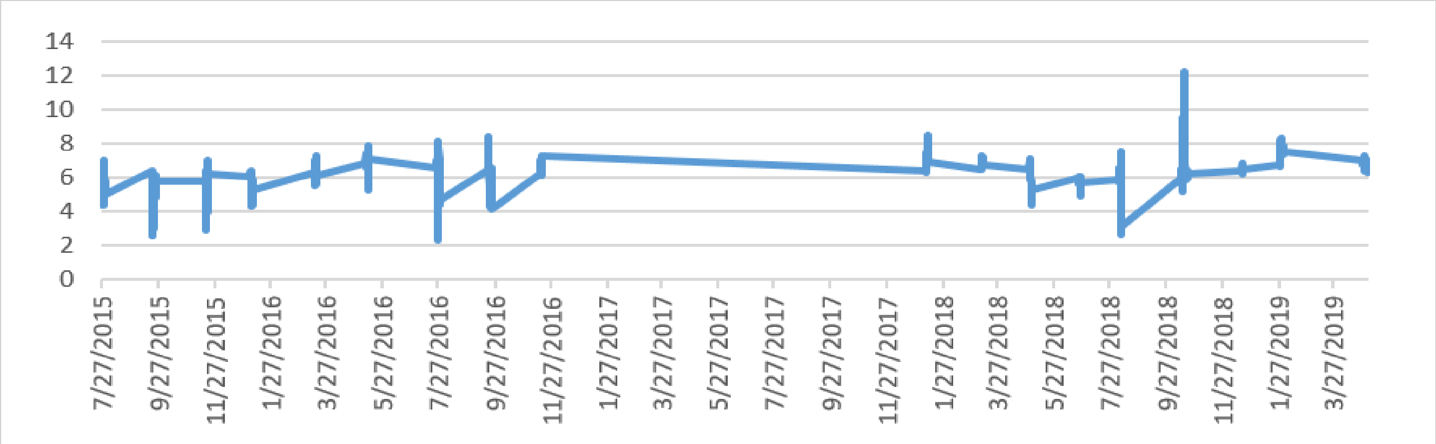



**Figure 54.** **Dissolved oxygen levels from all monitoring stations in the Florida Keys.**

## Soluble Reactive Phosphates and Dissolved Inorganic Phosphates

Low nutrient levels are a normal condition for the waters in which coral reef ecosystems are found. 90% of coral reefs in the world are located in waters with less than 0.20 umols/L phosphate concentrations (Kleypas, McManus and Menez, 1999). Florida Keys reefs followed this limit, though a spike was seen in 2013-2014. The trend in the last five years has remained in normal range and stable (Figure 54).

*Average DIP per Year*

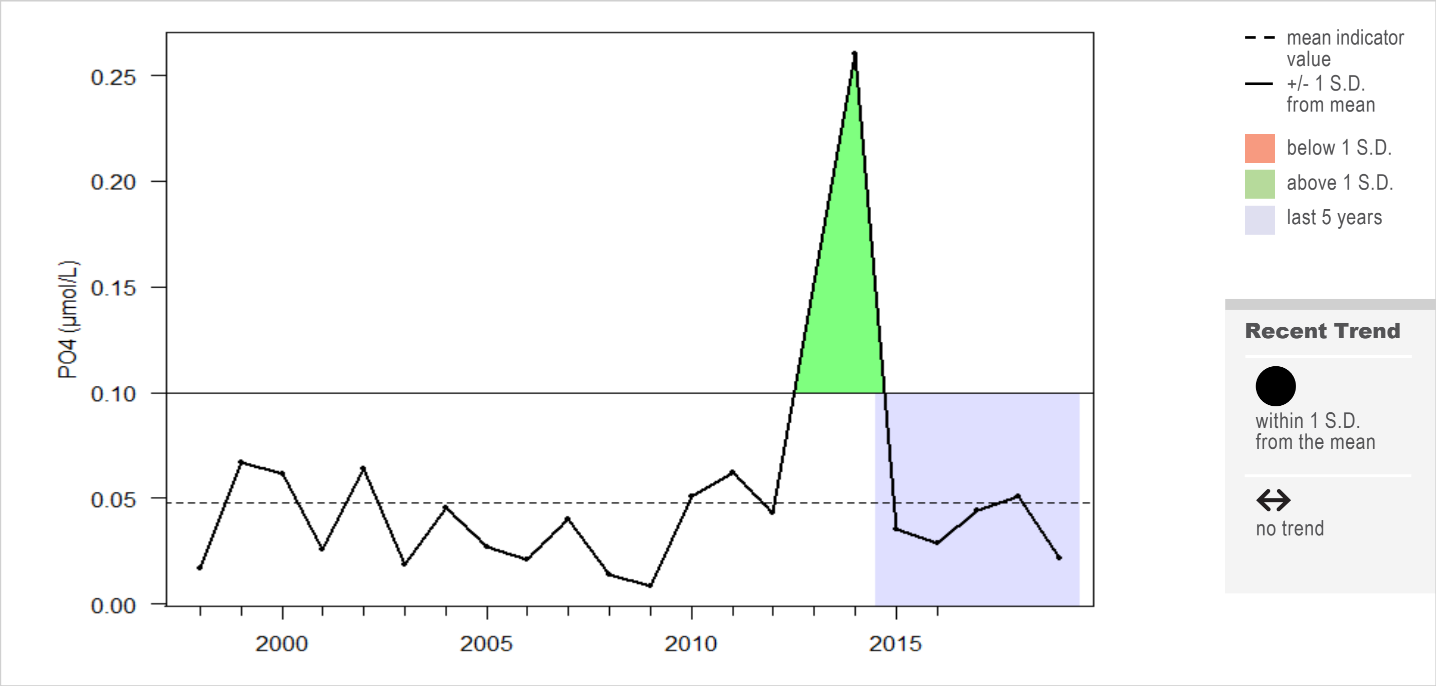



**Figure 55.** **Average level of phosphate for all Florida Keys stations, per year.**

## Chlorophyll A Levels on the Florida Reef Tract

Chlorophyll a is the green pigment found in the chloroplasts of plants, algae and other primary producers that conduct photosynthesis. Chlorophyll a concentrations are often used as an indicator of phytoplankton abundance and biomass in coastal and estuarine waters. Chlorophyll a is also used to approximate the amount of primary production occurring from phytoplankton (Bot and Colijn 1996). Phytoplankton growth depends on the availability of carbon dioxide, sunlight, and nutrients, and so elevated levels of chlorophyll a can indicate an upward trend in the amount of nutrient loading in coastal waters. Chlorophyll a levels have been measured bimonthly since 1998 at reef tract sites in the Florida Keys. This time series data shows two increases of more than one standard deviation above the mean in the time period of 2012-2013 and 2016-2017, though the overall trend has been stable for the past five years (Figure 55).

*Average Chlorophyll A Levels on Reef Tract Sites per Year*

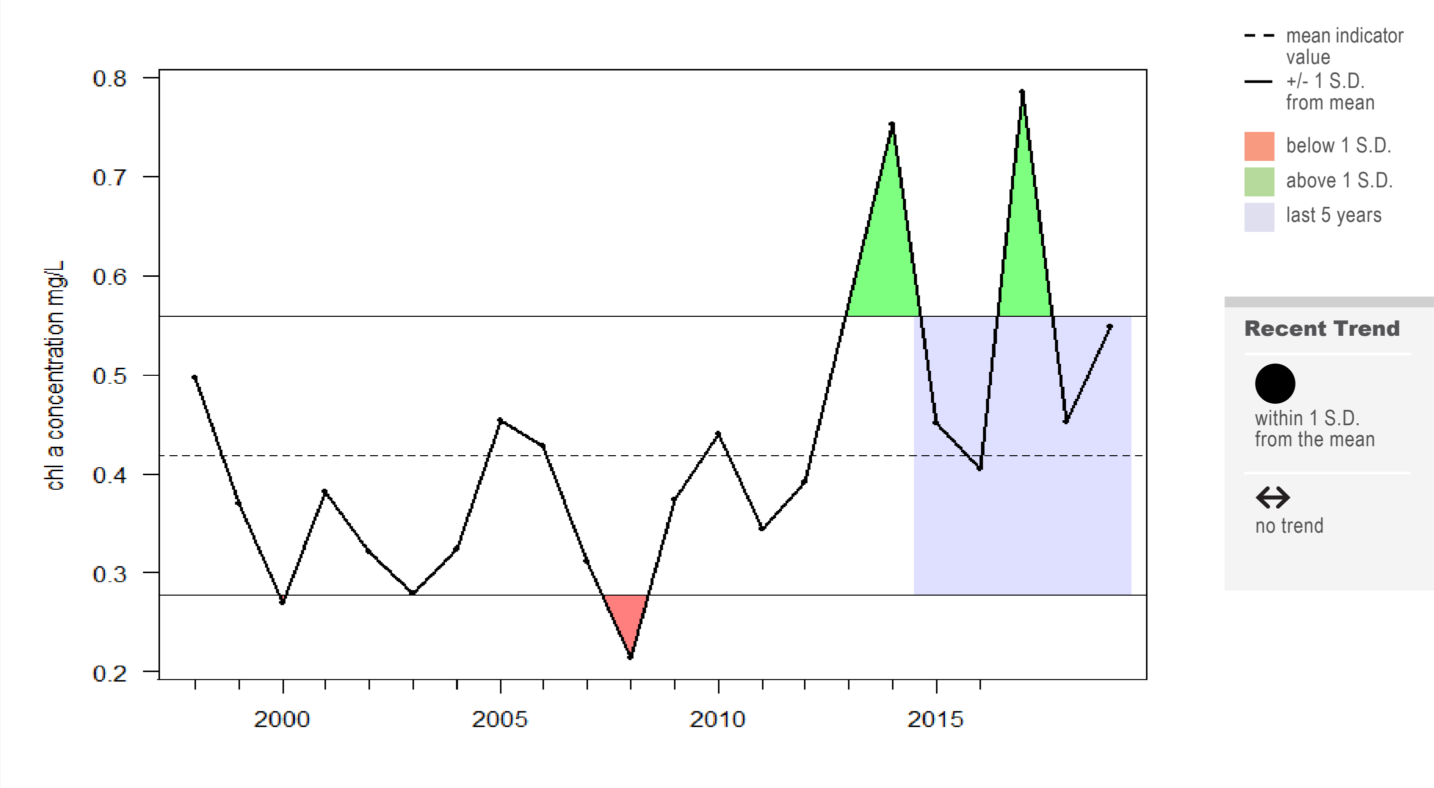



**Figure 56.** **Average chlorophyll a concentration for all Florida Keys reef tract stations, per year.**

## Fecal Indicators on Sanctuary Coastline — Levels and Beach Closure Advisories Issued

The presence of fecal indicator bacteria, fecal coliform and enterococci are measured by the Florida Healthy Beach program in order to advise beach closures due to threats to public health. The presence of these fecal indicators can be due to fecal pollution, which may come from stormwater runoff, pets and wildlife, and human sewage. If they are present in high concentrations in recreational waters and are ingested while swimming or come in contact with skin, they may cause human disease, infections or rashes (Florida Department of Health). This report uses the number of fecal indicator advisories issued on Florida Keys National Marine Sanctuary shoreline as an indicator of fecal bacteria presence as a threat to public health. In the Upper Keys, there has been a peak average of more than one standard deviation above the mean in advisories issued, from 2004 to 2006, and a low average of more than one standard deviation below the mean in advisories issued, from 2008 to 2011 (Figure 56). In the past five years, there has been an increasing trend in the number of beach closure advisories issued due to the presence of fecal indicators. In the Middle Keys, there has been a peak average of more than one standard deviation above the mean in advisories issued, from 2004 to 2006, and a low average of more than one standard deviation below the mean in advisories issued, from 2012 to 2014. In the past five years, there has been a stable trend in the number of beach closure advisories issued due to the presence of fecal indicators (Figure 57). In the Lower Keys, there has been a peak average of more than one standard deviation above the mean in advisories issued, from 2004 to 2007, and a low average of more than one standard deviation below the mean in advisories issued, from 2012 to 2016. In the past five years, there has been a stable trend in the number of beach closure advisories issued due to the presence of fecal indicators (Figure 58).

*Number of Fecal Indicator Related Advisories Issued in Upper Keys*

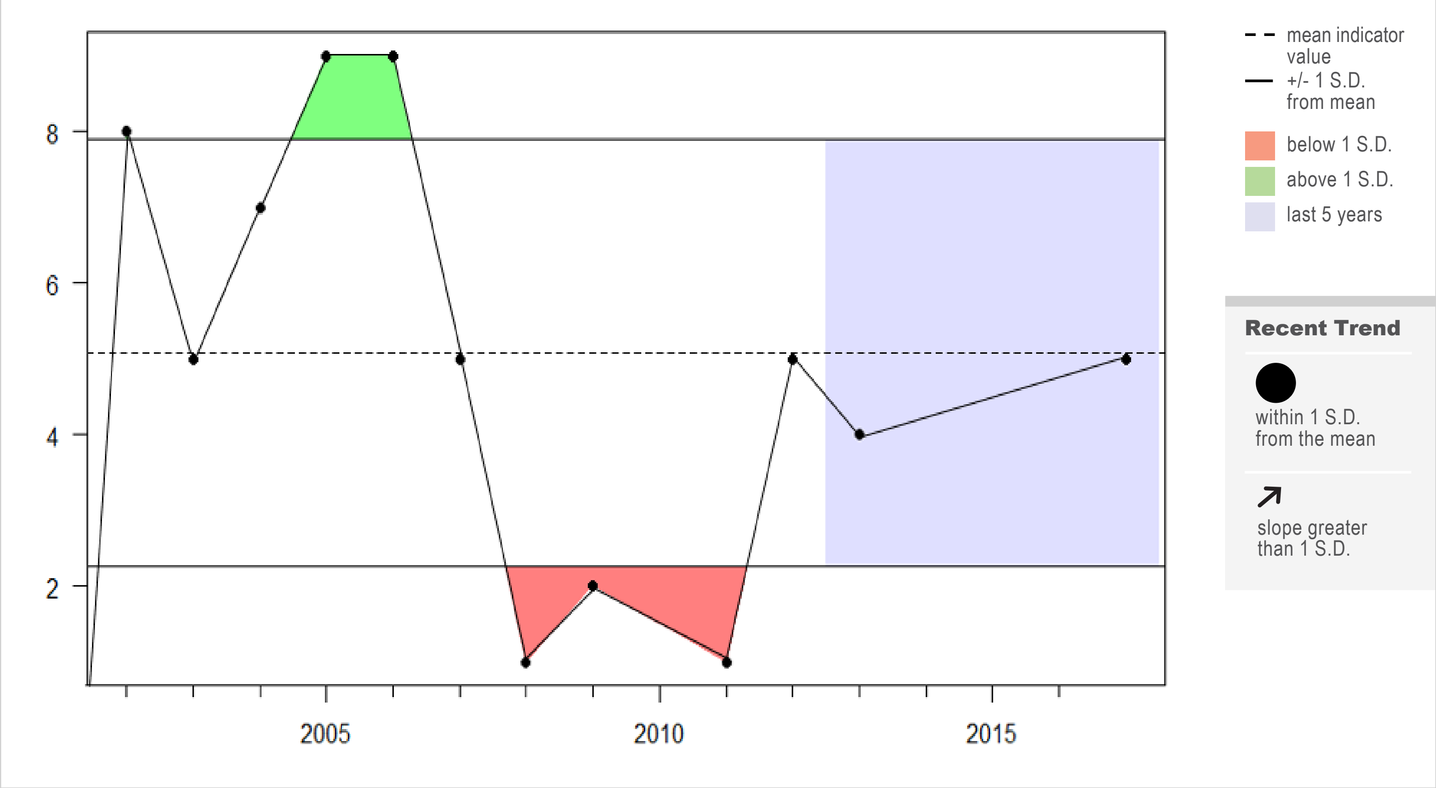



**Figure 57.** **Number of fecal indicator presence related public beach advisories issued in the Upper Keys per year.**

*Number of Fecal Indicator Related Advisories Issued in Middle Keys*

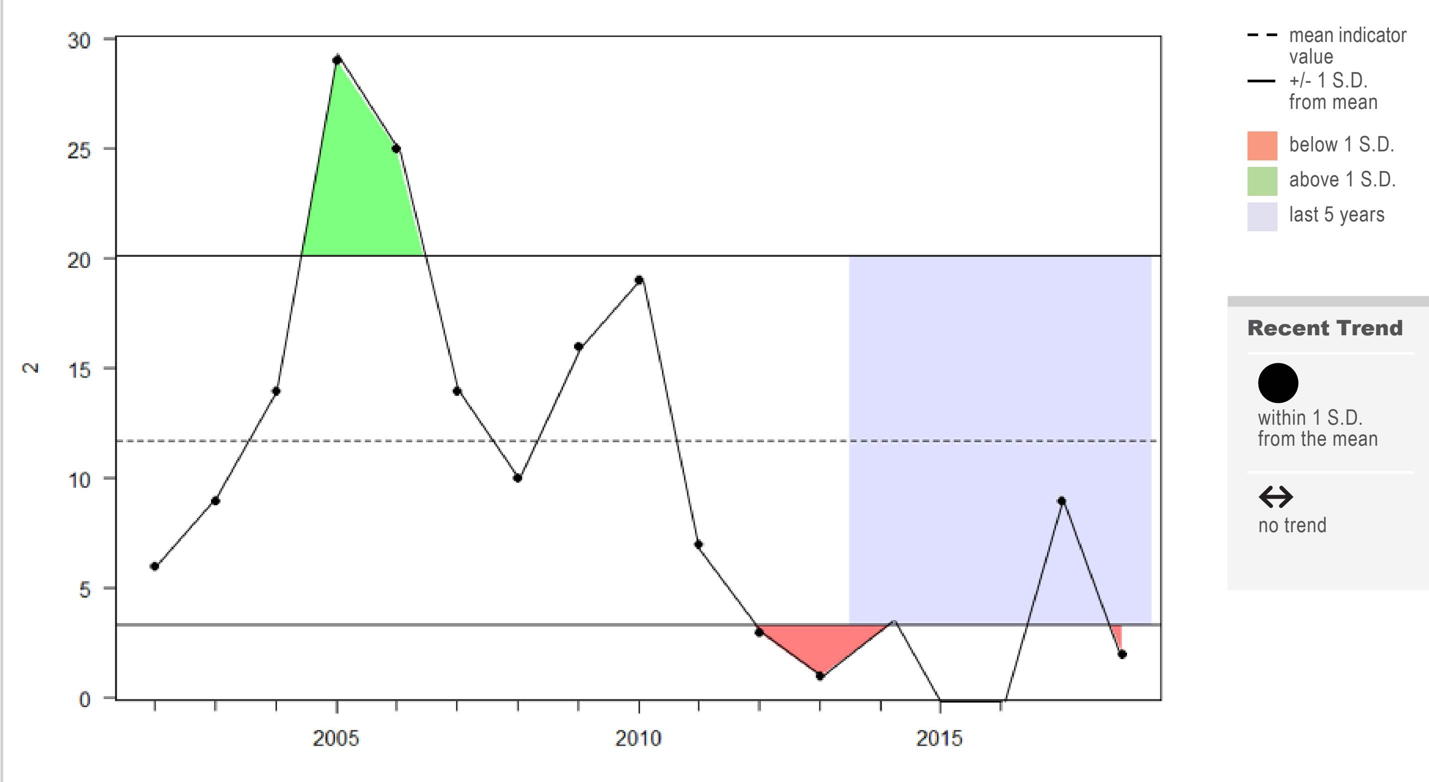



**Figure 58.** **Number of fecal indicator presence related public beach advisories issued in the Upper Keys per year.**

*Number of Fecal Indicator Related Advisories Issued in Lower Keys*

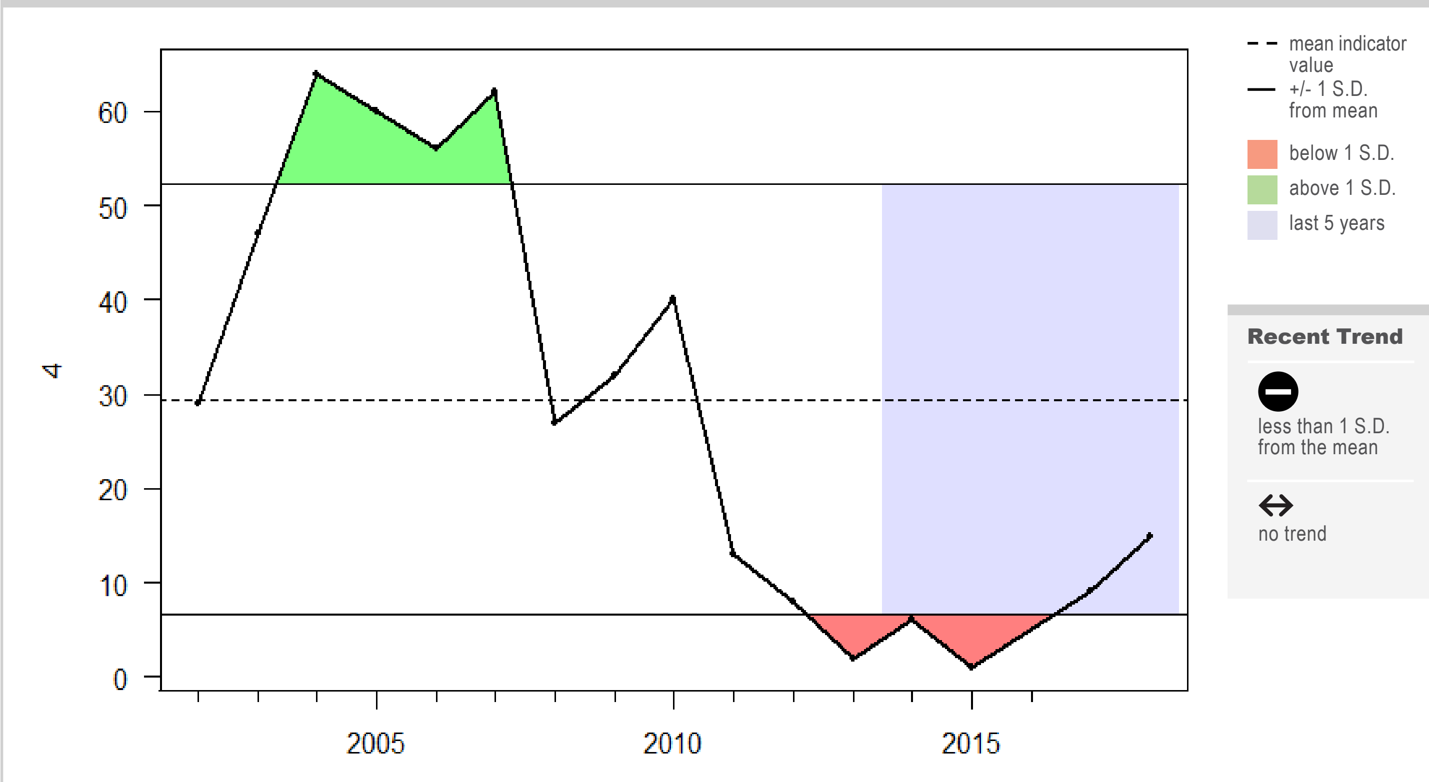



**Figure 59.** **Number of fecal indicator presence related public beach advisories issued in the Lower Keys per year.**

## Sea Surface Temperature Change

Sea Surface Temperature (SST) is a measure of the energy due to the motion of molecules at the top layer of the ocean (NASA Jet Propulsion Laboratory Physical Oceanography Earth Data). Rising sea surface temperatures affect many biological and physical oceanography processes, and mass coral bleaching has become one of the most visible marine ecological impacts of persistently rising ocean temperatures. The following time series of changes in sea surface temperatures in the Florida Keys is collected via satellite remote sensing measurements by NOAA's Coral Reef Watch program. An overall increasing SST trend of more than 1 degree Celsius in maximum temperature is seen in the Florida Keys (Figure 59).

*Sea Surface Temperature in Celsius in the Florida Keys Polygon, 1985-2019*

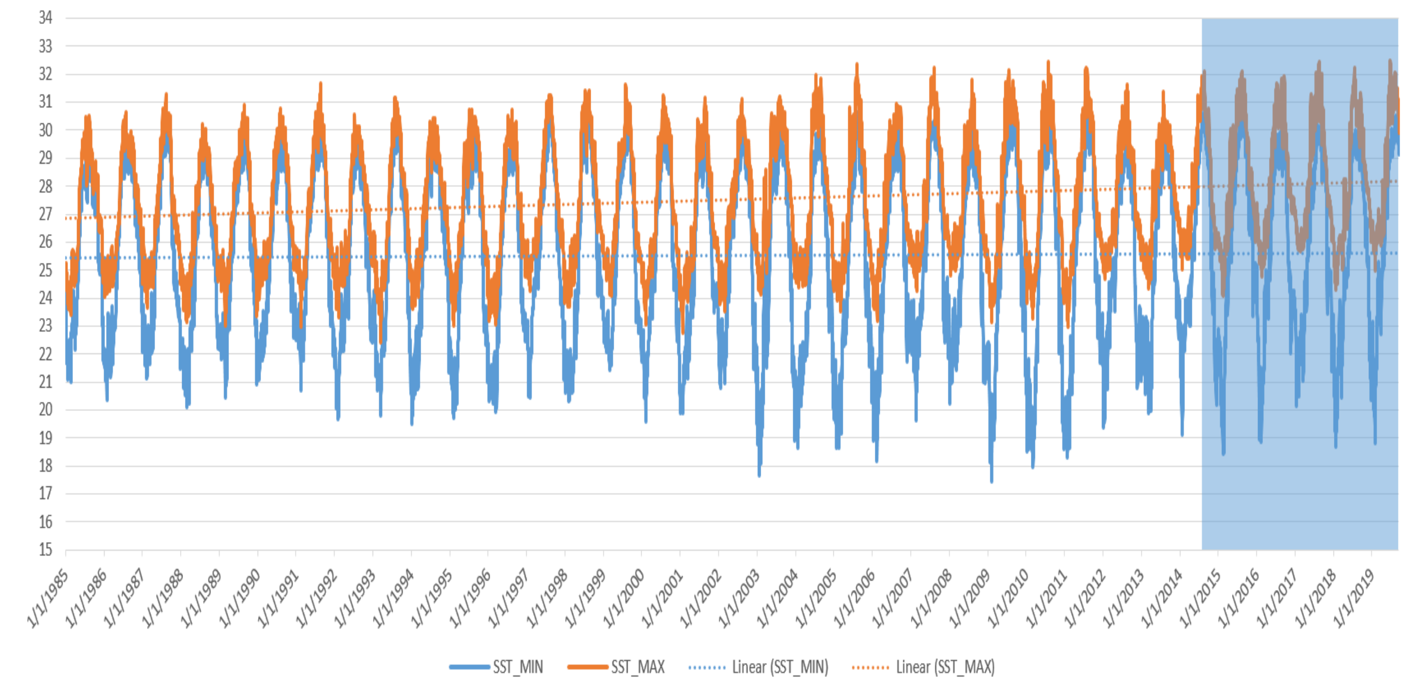



**Figure 60.** **Changes in sea surface temperature minimums and maximums in the Florida Keys via satellite measurements.**

# Maritime Archaeological Resources

Maritime heritage in National Marine Sanctuaries is a broad legacy that includes not only physical resources, such as historic shipwrecks and prehistoric archaeological sites, but also archival documents, oral histories, and traditional seafaring and ecological knowledge of indigenous cultures (NOAA Office of National Marine Sanctuaries). The goal of maritime heritage in the Sanctuaries is that a broad spectrum of Americans will be engaged in the stewardship and appreciation of our national maritime heritage. The condition of these nonrenewable resources can be impacted by human use, as well as natural factors such as storms, currents and corrosion.

## Number of Resources Listed on the National Register of Historic Places, Including Lighthouses

The National Register of Historic Places (NHRP) is the official list of historic buildings, districts, sites, structures, and objects worthy of preservation in the United States, established as part of the National Historic Preservation Act of 1966. The National Register recognizes more than 90,000 properties for their significance in American history, architecture, art, archeology, engineering, and culture (U.S. General Services Administration, National Register of Historic Places). The number of Florida Keys National Marine Sanctuary resources, including lighthouses, included on this list are used as an indicator of maritime heritage preservation. Inclusion of resources on the NHRP is also mandated by the National Historic Preservation Act, which directs all federal agencies to develop programs to protect historical and archaeological resources and requires agencies to actively search for archaeological resources and to assess them for their significance and eligibility for inclusion in the National Register of Historic Places. This number has been increasing from the designation of the Sanctuary, with an increase of over one standard deviation above the mean since 2006 (Figure 60).

***Total Number of Resources Listed on NHRP***

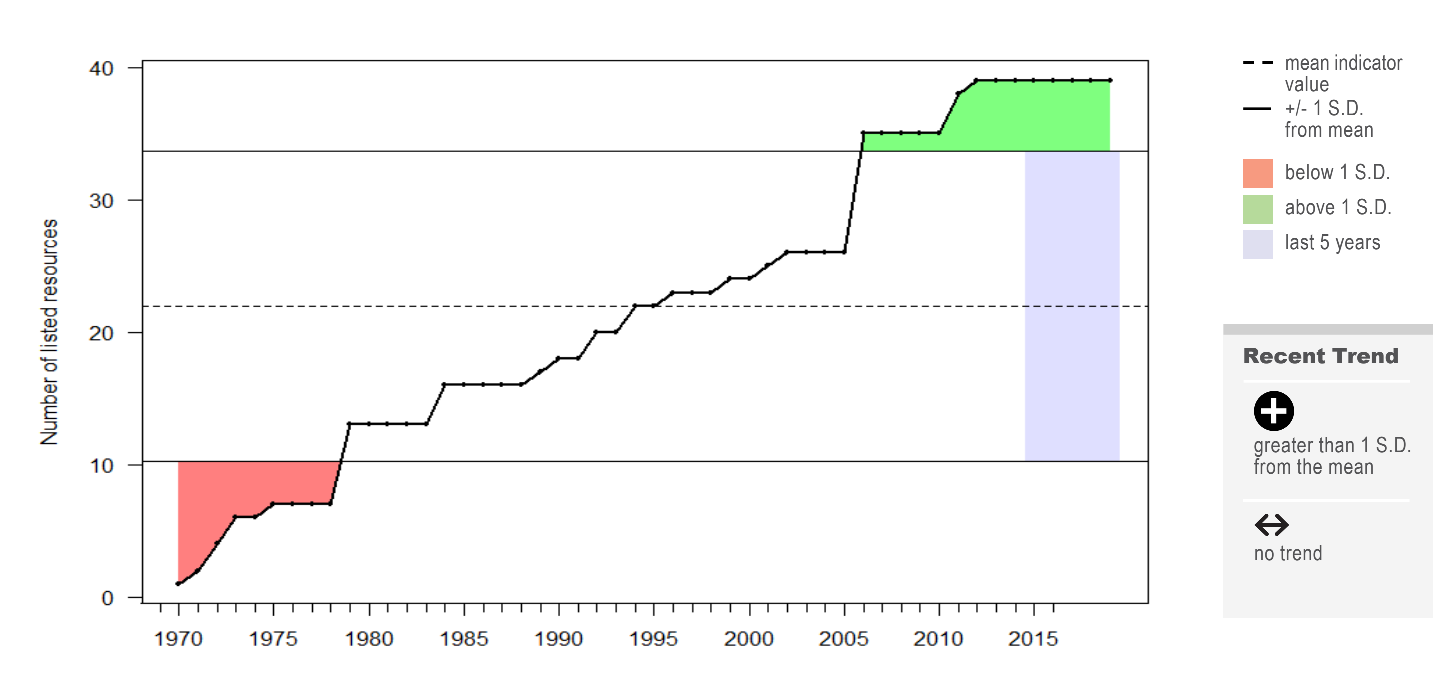



**Figure 61.** **Total number of maritime archaeological resources in the Florida Keys listed on the National Register of Historic Places.**

## Number of Maritime Heritage Sites Interpreted for Public Education and Outreach

The Florida Keys are rich in maritime history, but if these heritage resources and sites are not marked and explained to the public, it's not accessible as a public resource. Thus, total number of maritime heritage and archaeological resource sites that have been interpreted for public outreach is used in this report as an indicator of maritime heritage condition. This indicator has also been increasing since the designation of the Sanctuary, with an increase of over one standard deviation above the mean since 2014 (Figure 61).

***Total Number of MAR Sites Interpreted for Public Outreach and Education***

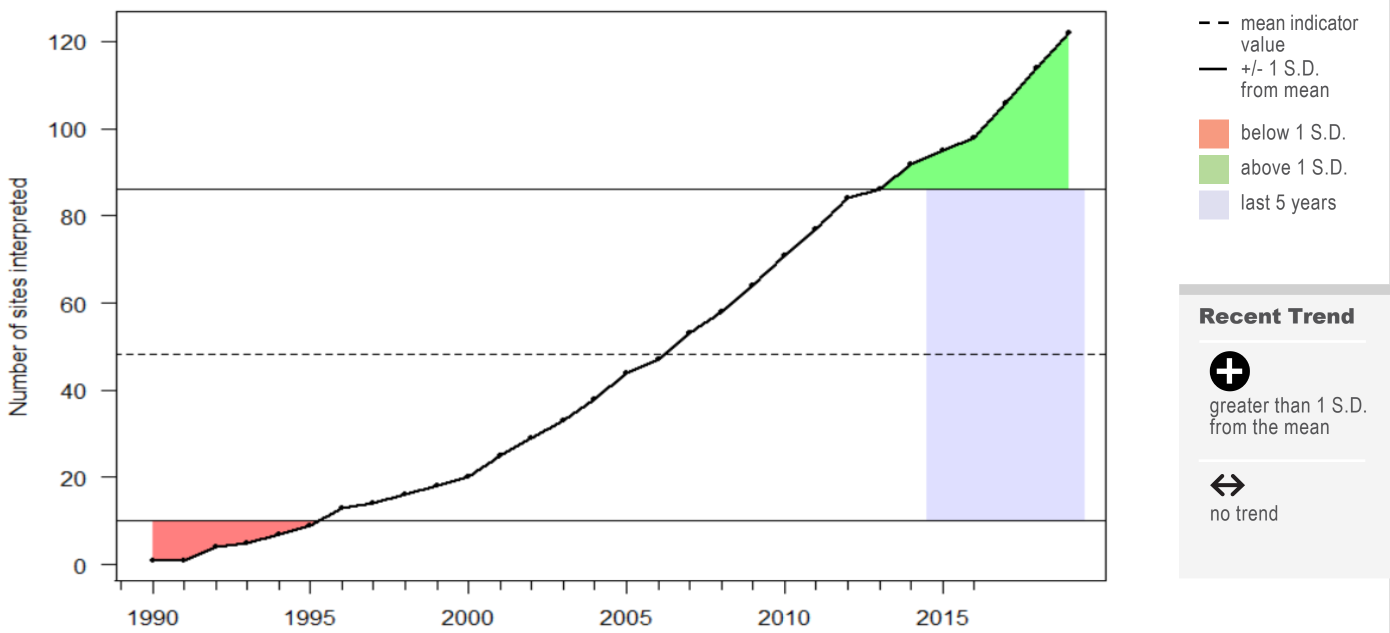



**Figure 62.** **Total number of maritime archaeological resources in the Florida Keys that have been interpreted for public outreach and education.**

## Level of Attendance and Participation of Stewardship Outreach Events

The maritime heritage program in FKNMS leads many opportunities for public outreach, education and stewardship. These events promote maritime heritage appreciation and allow the public to engage in stewardship and better understand the region's maritime heritage. The total number of participants and attendees per year in stewardship outreach events such as at heritage awareness seminars, public archaeology, heritage monitoring Scouts, citizen science, was thus selected as an indicator. This indicator has shown an increasing trend in the past five years as well as periods of increase of over one standard deviation above the mean since 2009.

### *Total Number of Participants in MAR Stewardship Events*

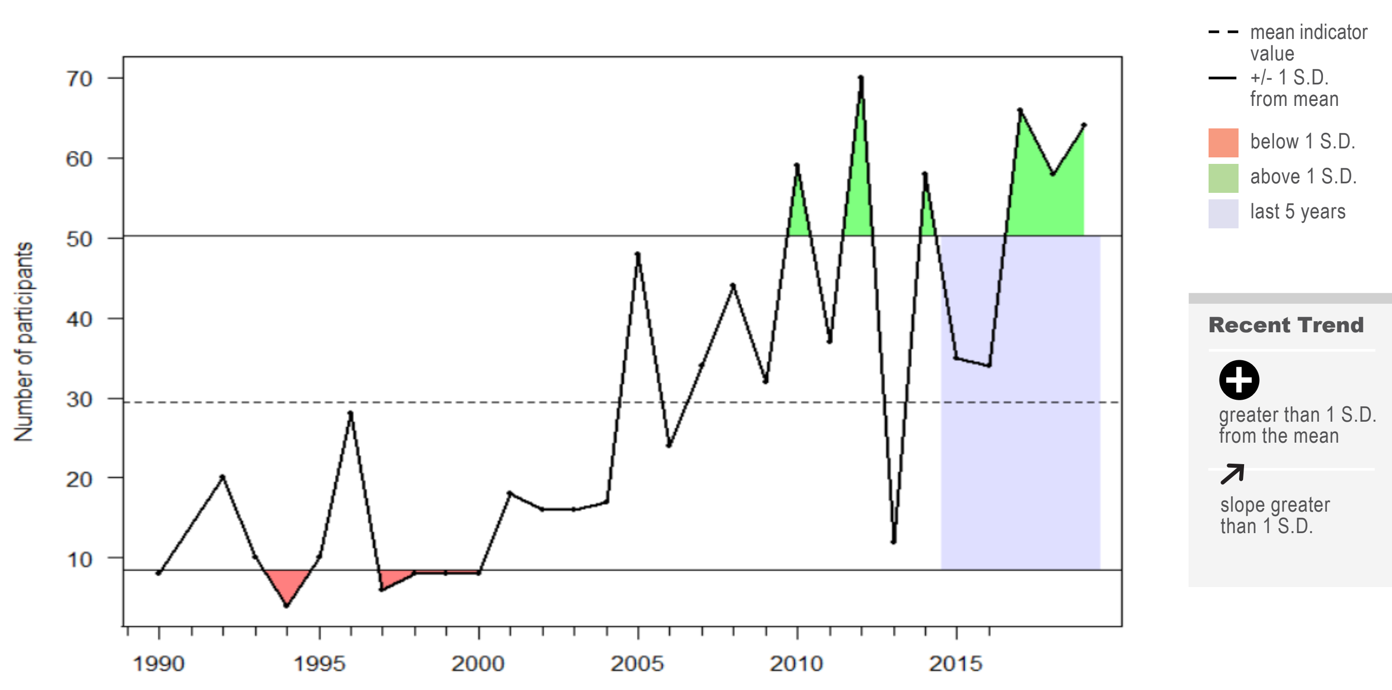



**Figure 63.** **Level of participation via number of participants per year in maritime archaeological resources stewardship and outreach events.**

# Uses and Broader Implications

This work is already being used in a variety of ways, and has numerous broader and collaborative uses planned for the future. With this work's partners at Florida Keys National Marine Sanctuary (FKNMS) the products and process are supporting a number of management needs of the site, including an upcoming update of their condition report. This started an effort by the IEA team to identify priority management needs related to proposed boundary changes and zoning, then the associated indicators that could be used to better understand the status of affected ecosystems under different management scenarios. The new FKNMS Restoration Blueprint (draft management plan) now includes natural resource and human-use indicators developed from the FKNMS IEA project to better understand the current state of the sanctuary. This project's indicator status and trends are used to set baseline conditions for the draft environmental impact assessment of the proposed FKNMS management plan. The developed and vetted indicator list has been requested and is being used by other agencies and projects; namely Florida Fish and Wildlife Conservation Commission's Fish and Wildlife Research Institute and NOAA's National Coral Reef Monitoring Program, in an effort to streamline and share common, quantitatively selected ecological and human use indicators. The IEA team is now collaborating with the sanctuary and academic partners associated with the Marine Biodiversity Observation Network to build interactive data access tools and interactive conceptual models to support Sanctuary science, management and outreach needs based on this project's selected indicators and analyzed status and trends.

### *Highlights*

*This work supports multiple Sanctuary management needs and is being used to:*

- *Update the condition report.*
- *Identify needs related to proposed boundary changes and zoning.*
- *Inform the new draft mangaement plan.*
- *Set baseline conditions for the draft environmental impact assessment of the proposed mangaement plan.*
- *Share indicators with other agencies and projects as requested.*
- *Collaborate with partners to build interactive data access tools and conceptual models.*

# Data Sources

| Indicator | Data Source |
|---|---|
| Resident Population Trends | Monroe County Records resident population, US Census |
| Wastewater Management Actions via Connections to Sewer | Monroe County Social Services Department, Florida Keys Aqueduct Authority |
| Tourist Population and Visitation Trends | Monroe County Tourism Development Council |
| Cruise Ship Visitors | Key West Chamber of Commerce |
| Total Tourism Value | NOAA Office for Coastal Management coastal economy dataset |
| Land Use Cover And Trends In Monroe County | NOAA National Ocean Service satellite information and Office for Coastal Management C-CAP program |
| Reef Structure As Coastal Protection | Storlazzi et al., USGS/UCSC report |
| Total Registered Vessels In Monroe County | Florida Department of Highway Safety and Motor Vehicles |
| Number Of Commercial Fishing Trips | Florida Fish and Wildlife Conservation Commission |
| Number Of Trips; Landed Amount Of Economically Important Species In The Florida Keys | Florida Fish and Wildlife Conservation Commission; NOAA National Marine Fisheries Service |
| Number Of Recreational Fishing Licenses Sold In Monroe County Per Year | Florida Fish and Wildlife Conservation Commission |
| Housing Disruption In The Florida Keys: Gentrification Pressure And Social Vulnerability | NOAA Office of Science and Technology coastal social vulnerability survey |
| Coral Species Richness | FWC Fish and Wildlife Research Institute Coral Reef Evaluation and Monitoring Project |
| Biodiversity Of Fishes In The Florida Keys National Marine Sanctuary | NOAA National Marine Fisheries Service, Southeast Fisheries Science Center, Reef Visual Census program |
| Abundance Of Selected Target Fish Species In Fknms | NOAA National Marine Fisheries Service, Southeast Fisheries Science Center, Reef Visual Census program |
| Abundance Of Invasive Lionfish In Fknms | NOAA National Marine Fisheries Service, Southeast Fisheries Science Center, Reef Visual Census program |
| Presence And Abundance Of Reef Builder Coral Species | FWC Fish and Wildlife Research Institute Coral Reef Evaluation and Monitoring Project |
| Mean Living Tissue Area Of Stony Coral In Fknms | FWC Fish and Wildlife Research Institute Coral Reef Evaluation and Monitoring Project |

| Indicator | Data Source |
|---|---|
| Mean Density Of Stony Coral Colonies In Fknms | FWC Fish and Wildlife Research Institute Coral Reef Evaluation and Monitoring Project |
| Endangered Species Act Listed Corals Seen On Surveys | NOAA National Coral Reef Monitoring Program surveys |
| Green Macroalgae Abundance | NOAA National Coral Reef Monitoring Program surveys |
| Seagrass Abundance | Florida International University Seagrass Ecosystems Research Lab |
| Sponge Abundance By Volume And Colony Count | FWC Fish and Wildlife Research Institute Coral Reef Evaluation and Monitoring Project |
| Macroalgae, Sponge And Soft Coral Percent Cover | NOAA National Coral Reef Monitoring Program surveys |
| Calcification Rates And Carbonate Budget, Site In The Middle Florida Keys | NOAA Atlantic Oceanographic and Meteorological Laboratory's Acidification, Climate, and Coral Reef Ecosystems Team, Ocean Chemistry and Ecosystems Division |
| Mangrove Land Cover In Monroe County | NOAA Digital Coast C-CAP |
| Nutrients: Dissolved Inorganic Phosphates On Reef Tract In Fknms | NOAA Atlantic Oceanographic and Meteorological Laboratory's South Florida Project, Ocean Chemistry and Ecosystems Division |
| Nutrients: Nitrate Suite Levels On Reef Tract In Fknms | NOAA Atlantic Oceanographic and Meteorological Laboratory's South Florida Project, Ocean Chemistry and Ecosystems Division |
| Chlorophyll A Levels On Reef Tract In Fknms | NOAA Atlantic Oceanographic and Meteorological Laboratory's South Florida Project, Ocean Chemistry and Ecosystems Division |
| Sea Surface Temperature | NOAA National Environmental Satellite, Data, and Information Service, Coral reef Watch program |
| Fecal Indicators On Sanctuary Beaches-Closures And Fecal Coliform Advisories Issued | Florida Healthy Beaches program; University of Miami Abess Center |
| Number Of Maritime Archaeological Sites Interpreted For Public Outreach And Education In Fknms | NOAA Office of National Marine Sanctuaries, Maritime Archaeology |
| Attendance At Maritime Archaeological Resource Community Interest Projects And Events | NOAA Office of National Marine Sanctuaries, Maritime Archaeology |
| Number Of Maritime Resources Listed On The National Register Of Historic Places | NOAA Office of National Marine Sanctuaries, Maritime Archaeology |

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