Atlantic Sturgeon and Sea Turtle Bycatch and Distribution

Based on data collected by the
North Carolina Division of Marine Fisheries
Programs 135, 356, 466, and 915

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3. Overview

This report provides findings on the spatial distribution of Atlantic sturgeon and sea turtle bycatch in North Carolina, as informed by data collected in NC Division of Marine Fisheries programs. This report is divided into two main sections, which are summarized below.

3.1 ATLANTIC STURGEON BYCATCH AND DISTRIBUTION

The purpose of this section of the report is to analyze data that have been collected by the North Carolina Division of Marine Fisheries (DMF) over the past 25 years, to better understand patterns of Atlantic sturgeon bycatch and distribution in North Carolina (NC) coastal waters and to determine the potential effects of gill net closures on sturgeon bycatch and catch of target species. This report uses data collected under DMF Programs 135, 356, 466, and 915, and is intended to serve as a reference and support tool for decisions related to the spatial management of Atlantic sturgeon in NC. This section of the report is divided into the following five subsections:

1. Individual Dataset Maps & Graphs: Monthly and seasonal maps of number of sturgeon, fishing effort, and sturgeon catch per unit effort for Programs 135, 466, and 915. Monthly and seasonal maps of cumulative sturgeon days for Program 356. Monthly and yearly graphs of sturgeon catch/telemetered sturgeon, effort, and catch per unit effort.

2. Merged Dataset Maps: Monthly and seasonal maps of sturgeon catch per unit effort, and sturgeon presence/absence using combined data from multiple datasets.

3. Predicted effect of gill net closures on catch of Atlantic sturgeon, southern flounder, and American shad in Western Albemarle Sound: Analysis of possible closures and their effect on sturgeon takes and catch rates of gill net target species using Program 466 data under different effort redistribution scenarios.

4. Higher resolution maps of telemetered sturgeon in the Cape Fear & Brunswick Rivers: Higher resolution maps of Program 356 data in the Cape Fear and Brunswick Rivers that could be used to support delineation of potential time-closures for minimizing interactions between the American shad fishery and Atlantic sturgeon.

5. Bycatch of sturgeon in float versus sink gill nets: Maps and tables that distinguish between the amount of sturgeon bycatch in float versus sink gill nets recorded in Program 466 in the Albemarle and Pamlico Sounds.

3.2 SEA TURTLE BYCATCH AND DISTRIBUTION

The purpose of this section of report is to analyze data that have been collected by the North Carolina Division of Marine Fisheries (DMF) to better understand patterns of sea turtle bycatch and distribution in the Shallow Water Gill Net Restricted Areas of Pamlico Sound, and to determine the potential effects of gill net closures on sea turtle bycatch and catch of target species. This report uses data collected under DMF Program 466, and is intended to serve as a reference and support tool for decisions related to the spatial management of sea turtles in NC. This section of the report is divided into the following three subsections:

1. Background: Provides background on the management of the southern flounder and sea turtle bycatch in the Shallow Water Gill Net Restricted Areas of Pamlico Sound.

2. Monthly & Seasonal Analysis: Monthly and seasonal analyses of sea turtle bycatch in Program 466, including: a) maps of sea turtle bycatch, fishing effort, and sea turtle bycatch per unit effort, b) an analysis of the effect of expanding Pamlico Sound inlet corridors on catch of sea turtles & southern flounder catch under multiple effort redistribution scenarios, and c) identification of statistically significant clusters (e.g. hot spots) of sea turtle bycatch using the tool Hot Spot Analysis (Getis-Ord Gi*) from the Spatial Analyst toolbox in ArcMap.

3. Biweekly Analysis: Biweekly analyses of sea turtle bycatch in Program 466, including: a) maps of sea turtle bycatch, fishing effort, and sea turtle bycatch per unit effort, and b) an analysis of the effect of expanding Pamlico Sound inlet corridors on catch of sea turtles & southern flounder catch under multiple effort redistribution scenarios.

4. Atlantic Sturgeon Bycatch and Distribution

4.1 INDIVIDUAL DATASET MAPS & GRAPHS

4.1.1 METHODS

4.1.1.1 DATASETS

Four different datasets collected by DMF were used in this analysis.

4.1.1.1.1 Program 135: Striped Bass Independent Gill net Survey

DMF Program 135 aims to monitor the status of striped bass stock in Albemarle Sound. The program has been running since 1990, and uses stratified random sampling over a 1X1-mile grid during the months of November through May. Data collection took place year-round for the first three years of the program, but switched to a November through May sampling season in 1993. During sampling, a series of float- and sink- monofilament gill nets (12 different mesh sizes ranging from 2.5 to 10 inches) are deployed for a total of 960 yards per sample and soak for 24 hours. The dataset was analyzed at this 960-yard level, and therefore mesh sizes and float versus sink nets were not differentiated. Latitude/longitude for individual sets are not recorded in the program, rather the grid cell within which the sample was made is taken as the location for each set. This is different from the rest of the programs, for which latitude/longitude coordinates are recorded for each sample. [1]

4.1.1.1.2 Program 915: Fisheries Independent Survey

DMF Program 915 was established to monitor the status and trends of many different stocks that are targeted by multiple fisheries. Although the program began in 2001, this report only used data collected from 2003 – 2014 in the Pamlico Sound, and from 2008 until 2014 in the Cape Fear River because data were collected in a consistent manner during these years. The program employs a stratified random sampling survey design in a series of 1X1-minute grids, and crews deploy an array of float and sink nets (8 different mesh sizes ranging from 3 to 6.5 inches) for a total of 480 yards per sample. Soak times are 12 hours or less, and vary throughout the season. Nets are fished in all months except for January. The dataset was analyzed at this 480-yard level, and therefore mesh sizes and float versus sink nets were not differentiated. Latitude and longitude are recorded for each 480-yard sample. [2]

4.1.1.1.3 Program 466: Sea Turtle Bycatch Monitoring

DMF Program 466 uses a fishery-dependent sampling design, in which observers go out with commercial, large and small mesh gill net fishermen and record the location, catch, and gear used along with many environmental variables. This program began in 2003 as part of the Incidental

Take Permit for sea turtles, and is used to estimate annual levels of sea turtle bycatch. It essentially covers the entire extent of the NC coast, but primarily encounters Atlantic sturgeon in the Albemarle and Pamlico sounds, so this report is restricted to the analysis of Program 466 data in these two waterbodies. Net lengths and soak times for the gear used by these fishermen averaged around 1000 yards and 20 hours, respectively. Both float and sink nets were used, and mesh sizes range from 3.5 to 7 inches. These data were analyzed at the haul level, rather than for individual nets, and latitude and longitude were recorded for each haul. [3]

4.1.1.1.4 Program 356: Electronic Tagging Database

DMF Program 356 aims to collect data on the movement, potential spawning sites, and winter/summer habitats of Atlantic sturgeon using acoustic telemetry tagging studies. Receivers (Vemco VR-2W data-logging hydrophones) are located in both the Albemarle Sound and Cape Fear River. The receiver locations were selected in order to track migration patterns in and out of river basins and other water bodies, rather than to provide a complete picture of where sturgeon are at any point of time in these water bodies. From 2011 – 2015 there have been 158 individual Atlantic sturgeon detected by DMF's array of receivers. Not all of these fish were tagged by DMF scientists; some of the sturgeon were tagged by other institutions that have given permission for the locations of the sturgeon they tagged to be used in this analysis. [4]

4.1.1.2 MAPS FOR PROGRAMS 135, 915, 466

For Programs 135, 915, and 466, individual records were mapped to a grid within the study area for easy comparison across datasets. Because the points in Program 135 were already mapped to a grid, this grid was used as the basis for a graticule that was extended across the entire NC coast. For each map, the value of the relevant parameter was summed up for all points (latitude/longitude coordinates) in each grid cell over a given time step. Grid cells that did not contain any data for that particular dataset were removed from the map.

Three types of maps were created for these programs:

1. <u>Number of sturgeon (Count)</u> [1] – display the number of sturgeon caught within a grid cell over a given time period.
2. <u>Effort</u> – display fishing effort summed up across all points within a grid over a given time period. Fishing effort was calculated as the product of net length (yards) and the amount of time gear was fished (days) at each location.
3. <u>Catch per unit effort (CPUE)</u> – display the number of sturgeon caught per unit of effort. CPUE is calculated as the sum of all sturgeon caught divided by the sum of all effort

[1] Number of sturgeon is sometimes referred to as the "count" parameter in this report.

within a grid cell over a given time period. These maps are essentially created by dividing the count maps by the effort maps.

4.1.1.3 MAPS FOR PROGRAM 356

Program 356 is substantially different from the other three programs, because there is no fishing gear involved in data collection, and therefore no fishing effort parameter. In addition, each record is spatially and temporally auto-correlated with the previous record (serial autocorrelation) because the dataset is tracking individual sturgeon movement through time and space. In order to display the data in a way that was comparable to the count data for the other three datasets, it was necessary to take a daily average of detection locations (calculated using a weighted arithmetic approach [5]) for each individual in order to reduce the spatiotemporal autocorrelation of records.

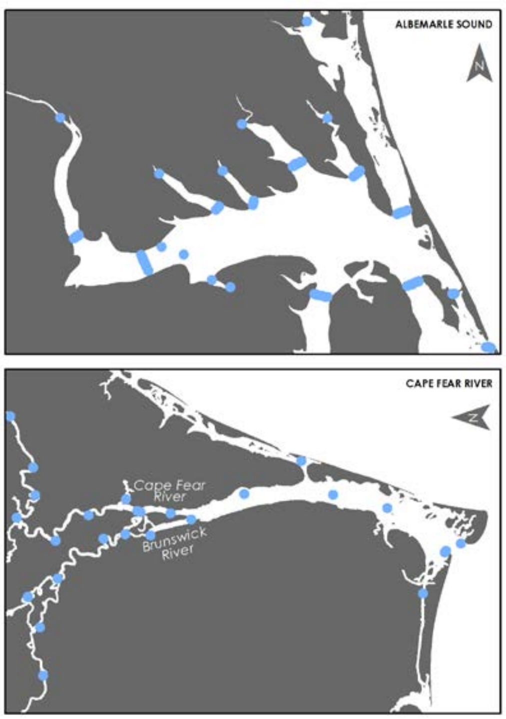


Figure 4.1. Program 356 receiver locations in the Albemarle Sound & Cape Fear River

The other problem presented by the 356 data is that there are no records of sturgeon absence[2], only records of where sturgeon were present in Albemarle and Cape Fear Rivers. In the other three programs there are fishing records in which no sturgeon were caught, providing an indication of locations where sturgeon may not be frequent inhabitants. To examine "pseudo absences" for Program 356 data, we displayed sturgeon absences as grid cells where at least one sturgeon's daily mean position had been located at some point over the course of the dataset, but was not located in that grid cell during the time period displayed on the map. In other words, if a telemetry-tagged sturgeon's daily mean position was located within a grid cell at some point in the study, we assumed that any telemetry-tagged sturgeon occurring in that grid

[2] The term "absence" as used in this report refers to a fishing event where no sturgeon were caught, or a location where no sturgeon were detected. However, it is possible that a sturgeon was present in a cell where an "absence" has been recorded, but was just not caught or detected by the receivers.

cell has a chance of being detected. The distribution of the telemetry receivers is such that there is not full spatial coverage of the water bodies (particularly in the Albemarle sound, see figure 4.1) and so areas where a sturgeon was not detected does not definitively indicate that sturgeon do not inhabit that area, but could also indicate that it was not possible to detect a sturgeon in that location on a particular day. The ability for a receiver to detect a telemetry tag signal is dependent on ambient noise in the environment such as wave height and biological noise [6], therefore the pseudo-absences on Program 356 maps should be interpreted with caution.

One type of map was created for Program 356:

1. Cumulative sturgeon days – display the number of times a telemetered sturgeon's mean daily position was located within a grid cell during a given time period. The value of the cumulative sturgeon days variable for a particular grid cell can surpass the number of days in a month or season, because the mean daily position of multiple telemetered sturgeon may be located in the same grid cell on the same day.

Maps of cumulative sturgeon days were created in two color schemes, comparable to the symbology used for the Programs 135, 466, and 915 count and CPUE maps for easy comparison to the other three datasets.

4.1.1.4 MAP SYMBOLOGY

The range of count, effort, and CPUE values varied widely between datasets and waterbodies, and so a common scale for each parameter could not be used across all maps. Instead, the range of values displayed across all time steps (e.g. seasons, months) on each map is divided into 5 equal classes so that the lightest color represents a value in the lowest 20% of that parameters' range in that region, and the darkest color represents a value in the top 20% of that parameters' range in that region for that particular dataset. On all maps the color grey represents either zero catch (Programs 135, 466, and 915) or a pseudo-absence (Program 356).

4.1.1.5 GRAPHS

Graphs of sturgeon catch or number of telemetered sturgeon, effort, and catch per unit effort were made to support the interpretation of the maps. Two types of graphs were made for each dataset by waterbody:

1. Yearly graphs: data broken down by year
2. Monthly graphs: data broken down by month

4.1.1.6 SPATIAL AND TEMPORAL EXTENT

The program description, spatial extent, and date ranges are presented for P135, P356, P466, and P915 in table 4.1 below.

Table 4.1. Program datasets description, spatial extent, and date ranges of data used to create maps and charts.

Program #	Description	Spatial extent	Date ranges
135	Striped Bass Independent Gillnet Survey	Albemarle Sound	1990 - 2015
356	Electronic Tagging Database	Albemarle Sound	2011 - 2015
		Cape Fear River	2011 - 2015
466	Sea Turtle Bycatch Monitoring	Albemarle Sound	2004 - 2006, 2008, 2012 - 2014
		Pamlico Sound	2003 - 2014
915	Fisheries Independent Assessment	Pamlico Sound	2003 - 2014
		Cape Fear River	2008 - 2014

4.1.1.7 SPATIAL AND TEMPORAL RESOLUTION

All maps display the data in 1X1-mile grid cells. A series of maps for each dataset were created on both a monthly and seasonal time step. The seasons are divided in the following way:

- Spring: March, April, May
- Summer: June, July, August
- Fall: September, October, November
- Winter: December, January, February

4.1.2 FIGURES

4.1.2.1 SEASONAL MAPS

- Catch per unit effort/cumulative sturgeon days - Appendix A pg. 48
- Number of sturgeon/cumulative sturgeon days - Appendix A pg. 55
- Effort - Appendix A pg. 62

4.1.2.2 MONTHLY MAPS

- Catch per unit effort/cumulative sturgeon days - Appendix A pg. 67
- Number of Sturgeon/cumulative sturgeon days - Appendix A pg. 74
- Effort - Appendix A pg. 81

4.1.2.3 SUMMARY GRAPHS

- Yearly graphs – Appendix A pg. 86
- Monthly graphs – Appendix A pg. 93

4.1.3 SUMMARY

- In gill nets, sturgeon had relatively high CPUEs in Albemarle Sound, moderate CPUEs in the Cape Fear River, and low CPUEs in Pamlico Sound.
- Sturgeon were caught or detected in Albemarle Sound, Pamlico Sound, and Cape Fear River in every month of the year
- In Albemarle Sound, the highest CPUEs/cumulative sturgeon days were in the mainstem and western part of the sound and lowest catches/cumulative sturgeon days were in the tributaries (with exception of Chowan and Roanoke Rivers).
- Telemetry detection information shows greater use of Cape Fear River than gill net catches in Program 915 would suggest.
- Tables 4.2 and 4.3 summarize the peak years and months of sturgeon catch per unit effort (Programs 135, 466, and 915) and cumulative sturgeon days (Program 356) for Albemarle Sound, Pamlico Sound, and the Cape Fear River.

Table 4.2. Peak years of sturgeon catch per unit effort/cumulative sturgeon days by waterbody and program dataset, based on Appendix Figures 39 - 45. Cells with an "X" indicate the peak years, grey cells indicate years that data was available from each program. c

Waterbody	**Program #**	**Year**																									
		1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Albemarle	135									X		X	X							X					X		
	356																							X			
	466																			X							
Pamlico	466																X	X									
	915															X	X	X									
Cape Fear	915																			X	X	X	X				
	356																								X		

Table 4.3. Peak months of sturgeon catch per unit effort/cumulative sturgeon days by waterbody and program dataset, based on of Appendix Figures 46 - 52. Cells with an "X" indicate the peak years, grey cells indicate months that data was available from each program.

Waterbody	**Program #**	**Month**											
		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Albemarle	135											X	
	356					X	X	X	X	X	X		
	466				X						X		
Pamlico	466											X	
	915				X								
Cape Fear	915				X							X	
	356					X	X	X	X	X	X		

4.2 MERGED DATASET MAPS

4.2.1 METHODS

The four datasets analyzed in this report overlap spatially and temporally in three different waterbodies along the NC coast: Albemarle Sound, Pamlico Sound, and Cape Fear/Brunswick River. To create a more complete picture of the spatiotemporal distribution of Atlantic sturgeon we combined data from multiple datasets onto a series of maps for each of these three waterbodies.

4.2.1.1 CATCH PER UNIT EFFORT MERGE

To merge datasets that have a common geographical extent and an effort component, effort and number of sturgeon caught were summed up across all data points from both datasets within each grid cell (using the same grid as used in section 4.1 maps, described 4.1.1.2). Catch per unit effort was then calculated at the grid cell level by dividing the total sturgeon catch by total effort (see equation 1). This methodology was used to create maps of P915 and P466 in the Pamlico Sound, and P135 and P466 in the Albemarle Sound.

Equation 1.

$$\text{Sturgeon bycatch per unit effort for each grid cell} = \frac{\text{Total sturgeon catch from Program A in grid cell} + \text{Total sturgeon catch from Program B in grid cell}}{\text{Total effort from Program A in grid cell} + \text{Total effort from Program B in grid cell}}$$

4.2.1.2 PRESENCE/ABSENCE MERGE

The metric presence/absence of sturgeon was used to merge catch (P135, P466, and P915) and telemetry data (P356). To illustrate this methodology, the merge of datasets 135, 356, and 466 will be considered below.

For each grid cell for Program 135, there were three possible outcomes:

- **Presence** - one or more sturgeon were caught in that grid cell
- **Absence** - fishing occurred in that grid cell but no sturgeon were caught
- **NoData** - no fishing occurred in that grid cell

For each grid cell for Program 466, there were three possible outcomes:

- **Presence** - one or more sturgeon were caught in that grid cell
- **Absence** - fishing occurred in that grid cell but no sturgeon were caught

- **NoData** - no fishing occurred in that grid cell

For each grid cell for Program 356, there were three possible outcomes:

- **Presence** – one or more telemetered sturgeon had a mean daily position located in that grid cell
- **Pseudo-absence** – no sturgeon had a mean daily position in that grid cell during the time period under consideration, however at some point during the dataset one or more telemetered sturgeon had a mean daily position in that grid cell. See section 4.1.1.3 for more information on pseudo-absences.
- **NoData** - no telemetered sturgeon ever had a mean daily position located in that grid cell during any time period.

After the data had been coded in this way, all three datasets were compiled into the grid so that each cell contained information on the number of presences, absences, and NoData values across all datasets.

Table 4.4. Possible combinations of values in presence/absence merge.

	Program 135	Program 466	Program 356	Description
Possible Grid Cell Value Combinations	NoData	NoData	NoData	0 presence, 0 absence, 3 NoData (not shown on map)
	Absence	Absence	Absence	0 presence, 3 absence, 0 NoData
	NoData	Absence	Absence	0 presence, 2 absence, 1 NoData
	Absence	NoData	Absence	
	Absence	Absence	NoData	
	NoData	Absence	NoData	0 presence, 1 absence, 2 NoData
	NoData	NoData	Absence	
	Absence	NoData	NoData	
	Absence	Absence	Presence	1 presence, 2 absence, 0 NoData
	Presence	Absence	Absence	
	Absence	Presence	Absence	
	Presence	Absence	NoData	1 presence, 1 absence, 1 NoData
	Presence	NoData	Absence	
	NoData	Presence	Absence	
	NoData	Absence	Presence	
	Absence	NoData	Presence	
	Absence	Presence	NoData	
	Presence	NoData	NoData	1 presence, 0 absence, 2 NoData
	NoData	NoData	Presence	
	NoData	Presence	NoData	
	Presence	Absence	Presence	2 presence, 1 absence, 0 NoData
	Presence	Presence	Absence	
	Absence	Presence	Presence	
	Presence	NoData	Presence	2 presence, 0 absence, 1 NoData
	Presence	Presence	NoData	
	NoData	Presence	Presence	
	Presence	Presence	Presence	3 presence, 0 absence, 0 NoData

This resulted in ten unique combinations of presences, absences, and NoData values from each dataset for each grid cell (table 4.4). Grid cells for which all program datasets had "NoData" values were not displayed on the maps. A ranking for the remaining nine of these value combinations was calculated using the following formula:

Equation 2.

$$\text{Index of sturgeon presence} = \frac{\text{If at least one presence is recorded: Number of presences; if no presences are recorded: -1* the number of absences } \textit{(possible values: +3 to -3)}}{\text{Number of datasets with at least 1 record } \textit{(possible values: 1, 2, or 3)}} \times \text{Uncertainty Factor} \times 100$$

where the Uncertainty Factor is a value that downweights the percent of datasets with presences or absences if the grid cell does not contain all three datasets. The Uncertainty Factor is calculated as:

Equation 3.

$$\text{Uncertainty Factor} = 1 - \left[\text{Proportion of datasets not present in the grid cell } \textit{(possible values: 0, 0.33, or 0.667)} \times \text{Probability that the value for the missing dataset(s) would be a presence or absence } \textit{(value: 0.5)} \right]$$

The unique combinations of presence, absence, and NoData (figure 4.2, tables 4.5, 4.6, & 4.7) and Excel formulas from combining equations 2 and 3 (figure 4.2, tables 4.8, 4.9, & 4.10) were used to calculate an "index of sturgeon presence" (figure 4.2, tables 4.11, 4.12, & 4.13). These index values were then used to give a general ranking of catching or detecting a sturgeon. The ranking makes intuitive sense. For example, the value of *cell A* in table 4.12 falls in between the values of *cell B* and *cell C* of table 4.11. This is because the value of the third dataset is unknown in *cell A* (e.g. NoData) but if it were known, it would either be a presence or a (pseudo-) absence, making it of equal likelihood that the value of *cell A* would become equal to that of *cell B* or *cell C.*

This methodology was used to create merged dataset maps for Program 135, 466, and 356 in the Albemarle Sound, and for Programs 915 and 356 in the Cape Fear River.

Figure 4.2. Presence/absence merge index calculations.

Table 4.5

	3 programs with data		
	# Presences	# Absences	# NoData
Row 1	3	0	0
Row 2	2	1	0
Row 3	1	2	0
Row 4	0	3	0
	Column A	Column B	Column C

Table 4.6

2 programs with data		
# Presences	# Absences	# NoData
2	0	1
1	1	1
0	2	1
Column D	Column E	Column F

Table 4.7

1 program with data		
# Presences	# Absences	# NoData
1	0	2
0	1	2
Column G	Column H	Column I

Tables 4.5, 4.6, & 4.7. Unique combinations of Presence, Absence, or NoData possible in a map grid cell, where each row corresponds to the possible values in one grid cell. The combinations are sorted into 3 different tables depending on the number of programs that had data recorded in a cell.

Table 4.8

3 programs with data
Index Calculation Formula
=(IF(A1>0,A1,-B1)/(3-C1))*(1-(C1/3*0.5))*100
=(IF(A2>0,A2,-B2)/(3-C2))*(1-(C2/3*0.5))*100
=(IF(A3>0,A3,-B3)/(3-C3))*(1-(C3/3*0.5))*100
=(IF(A4>0,A4,-B4)/(3-C4))*(1-(C4/3*0.5))*100

Table 4.9

2 programs with data
Index Calculation Formula
=(IF(D1>0,D1,-E1)/(3-F1))*(1-(F1/3*0.5))*100
=(IF(D2>0,D2,-E2)/(3-F2))*(1-(F2/3*0.5))*100
=(IF(D3>0,D3,-E3)/(3-F3))*(1-(F3/3*0.5))*100

Table 4.10

1 program with data
Index Calculation Formula
=(IF(G1>0,G1,-H1)/(3-I1))*(1-(I1/3*0.5))*100
=(IF(G2>0,G2,-H2)/(3-I2))*(1-(I2/3*0.5))*100

Tables 4.8, 4.9, & 4.10. The index value calculations, using the formula shown in equations 2 and 3. Calculation formulas refer to the Presence, Absence, and NoData values in tables 5, 6, and 7 using the row numbers and column letters shown on the above tables.

Table 4.11

3 programs with data	
Index Calculation Result	
cell B	100
cell C	67
	33
	-100

Table 4.12

2 programs with data	
Index Calculation Result	
cell A	83
	42
	-83

Table 4.13

1 program with data
Index Calculation Result
67
-67

Tables 4.11, 4.12, & 4.13. Results of the index value calculations shown in tables 8, 9, and 10.

4.2.1.3 MERGED DATASETS LIMITED TO COMMON DATE RANGES

Two types of merged data maps were created using the methods outlined in sections 4.2.1.1 and 4.2.1.2. The first type includes all data from each of the datasets in the merge. The second type only includes data within date ranges common to all three datasets. The latter approach limited the amount of data that could be used to create the maps considerably, but is possibly a more trustworthy depiction of sturgeon distribution.

4.2.2 FIGURES

4.2.2.1 SEASONAL MAPS

- Catch per unit effort merge – Appendix A pg. 100
- Presence/Absence merge - Appendix A pg. 102
- Catch per unit effort merge, only common date ranges – Appendix A pg. 104
- Presence/Absence merge, only common date ranges - Appendix A pg. 106

4.2.2.2 MONTHLY MAPS

- Catch per unit effort merge – Appendix A pg. 108
- Presence/Absence merge - Appendix A pg. 110
- Catch per unit effort merge, only common date ranges – Appendix A pg. 112
- Presence/Absence merge, only common date ranges - Appendix A pg. 114

4.2.3 SUMMARY

- The merged dataset maps confirmed summary conclusions from section 4.1.3 and give a more complete spatial coverage of sturgeon distribution for Pamlico and Albemarle Sounds.
- The merged dataset maps for Program 915 and 356 datasets in Cape Fear River (Appendix A, figures 56, 60, 64, & 68) are likely not useful for management purposes, because there are so few sturgeon caught in Program 915 between 2003 and 2014. Merging these two datasets does not provide much additional information, and in fact may confound the true trends occurring in the Program 356 dataset.

4.3 PREDICTED EFFECT OF GILL NET CLOSURES ON CATCH OF ATLANTIC STURGEON, SOUTHERN FLOUNDER, & AMERICAN SHAD

4.3.1 PURPOSE

The purpose of this analysis is to predict the effect of potential gill net closures on the levels of Atlantic sturgeon bycatch and the catch of target species in DMF management unit A (Albemarle Sound).

4.3.2 METHODS

4.3.2.1 DELINEATION OF CLOSURE BOUNDARIES

Potential boundaries for the closures were chosen based on easily enforceable markers (figure 4.3). Starting in the west and moving eastward these were:

1. The 17 bridge
2. A set of power lines that cross the sound (Powerlines)
3. The 32 bridge
4. A line that runs from Bluff Point on the northern side of the sound to Laurel Point on the southern side of the sound, near Laurel Point Lighthouse (Lighthouse)
5. And a line that runs from Harvey's Point on the northern side of the sound to the eastern side of Bull Bay (Bull Bay/Scuppernong)

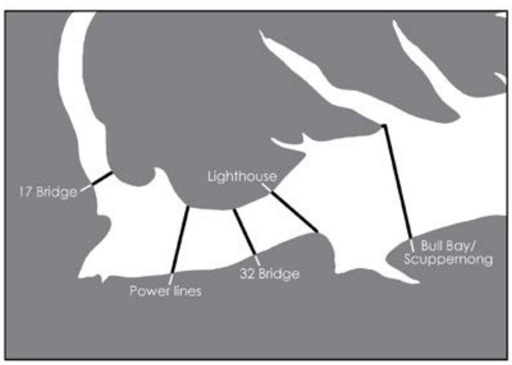
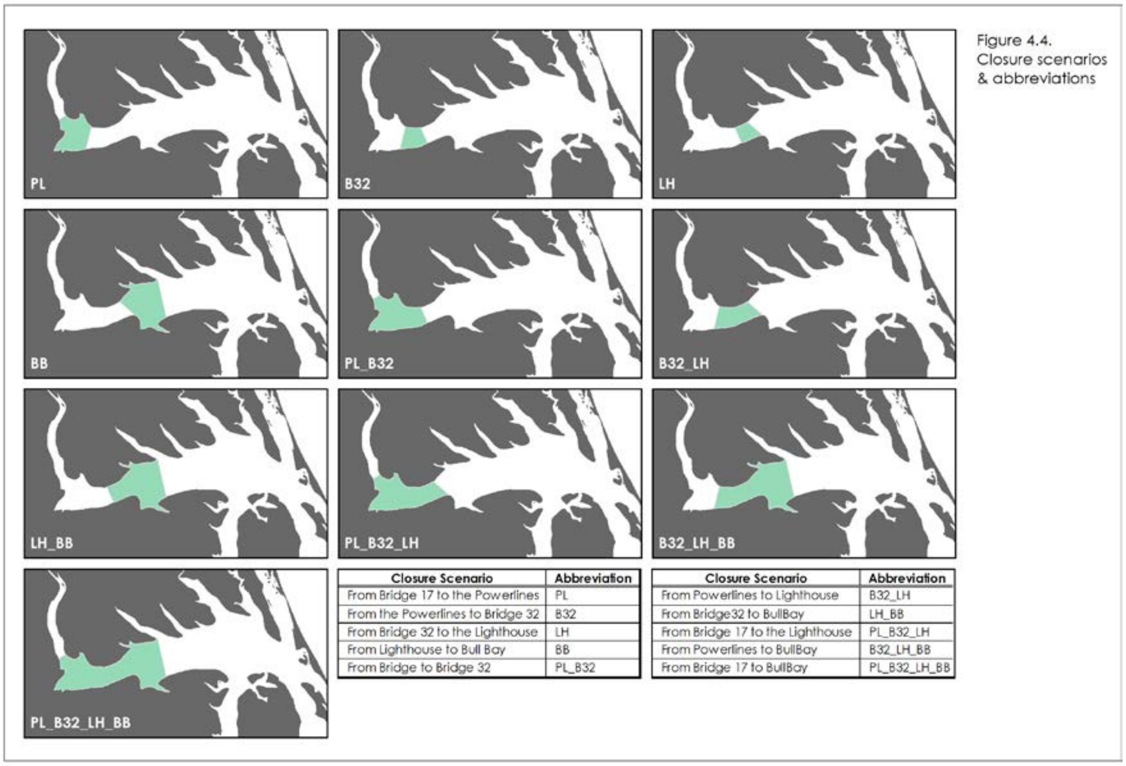


Figure 4.3. Potential closure boundaries based on easily enforceable markers

The effect of closing all possible combinations of areas as constrained by these boundaries with the stipulation of no non-adjacent closures was investigated. Figure 4.4 shows the ten different closures scenarios. These closure boundaries were overlaid on the Atlantic sturgeon, southern flounder, and American shad catch per unit effort maps from Program 466 (Appendix A, figures 69, 70, & 71).



Closure Scenario	Abbreviation
From Bridge 17 to the Powerlines	PL
From the Powerlines to Bridge 32	B32
From Bridge 32 to the Lighthouse	LH
From Lighthouse to Bull Bay	BB
From Bridge to Bridge 32	PL_B32

Closure Scenario	Abbreviation
From Powerlines to Lighthouse	B32_LH
From Bridge32 to BullBay	LH_BB
From Bridge 17 to the Lighthouse	PL_B32_LH
From Powerlines to BullBay	B32_LH_BB
From Bridge 17 to BullBay	PL_B32_LH_BB

Figure 4.4. Closure scenarios & abbreviations

4.3.2.2 CALCULATING EFFORT REDISTRIBUTION

The percent change in Atlantic sturgeon, southern flounder, and American shad catch in Albemarle Sound under different closures scenarios was calculated assuming that all effort/catch in the proposed closures would not have occurred within those closures during the years that sampling took place (2004-2006, 2008, & 2012-2014). Predicted change in effort as caused by effort redistribution was calculated at each individual fishing site (latitude/longitude coordinate) and new catch estimates were calculated by multiplying the predicted effort by the original catch per unit effort estimates.

4.3.2.2.1 Effort Redistribution Scenarios

1. No redistribution: All displaced effort is eliminated completely, e.g. all effort that occurred within the proposed closed area is removed and not reallocated to other fishing sites.
2. Even redistribution: All displaced effort is shifted into areas where fishing is allowed within management unit A, and is redistributed evenly across known fishing sites.
3. Proportional redistribution: All displaced effort is shifted into areas where fishing is allowed within management unit A, and is redistributed across known fishing sites proportionally to recorded effort in that location (i.e. sites with high effort would get allocated a larger percentage of displaced effort).

4. Inverse distance weighted redistribution: All displaced effort is shifted into areas within 30km of the closed area boundaries, and is redistributed across known fishing sites in an inverse distance weighted manner from the closed area boundaries (i.e., more of the effort is reallocated to fishing sites in close proximity to the closed areas).

4.3.2.3 SPATIAL & TEMPORAL EXTENT/RESOLUTION

All available data from Program 466 in Albemarle Sound was used in this analysis (2004 - 2006, 2008, 2012 - 2014). Although the effort redistribution analysis was run using the point locations of fishing events, maps of the potential boundary lines overlaid on top of gridded maps of catch per unit effort for all three species were created to help with interpretation of analysis results. These maps used the same 1x1 mile grids as were used in sections 4.1 and 4.2 of this report. The analysis was run for American shad during the winter and spring seasons, and for Atlantic sturgeon and southern flounder for all four seasons. The seasons were divided in the following way:

- Spring: March, April, May
- Summer: June, July, August
- Fall: September, October, November.
- Winter: December, January, February

4.3.3 TABLES

- Spring, Atlantic sturgeon – Appendix A pg. 119
- Spring, southern flounder – Appendix A pg. 122
- Spring, American shad – Appendix A pg. 124
- Summer, Atlantic sturgeon – Appendix A pg. 126
- Summer, southern flounder – Appendix A pg. 129
- Fall, sturgeon – Appendix A pg. 131
- Fall, southern flounder – Appendix A pg. 134
- Winter, Atlantic sturgeon – Appendix A pg. 136
- Winter, southern flounder – Appendix A pg. 139
- Winter, American shad – Appendix A pg. 141

4.3.4 RESULTS & DISCUSSION

The results of the effort redistribution analysis are contained in a series of tables in Appendix A, pages 119 – 142. There are three types of tables. The first two types were created for sturgeon, flounder, and shad:

1. The first table shows the absolute (number of individuals) change in catch in each of the different effort redistribution scenarios (columns) described in section 4.3.2.2.1, for each of the different closure scenarios (rows) shown in figure 4.4.
2. The second table shows the relative (percent) change in catch in each of the different effort redistribution scenarios (columns) described in section 4.3.2.2.1, for each of the different closure scenarios (rows) shown in figure 4.4.

The third type of table was created only for sturgeon:

3. The third table quantifies the efficiency of each closure scenario in terms of the reduction of sturgeon takes relative to the amount of area closed to fishing, and the amount of effort displaced. Only the results of effort redistribution scenarios 3 and 4 are displayed because these are "worst case" scenarios (meaning that pre- and post- closure effort remains the same), and the assumptions in these scenarios (that effort would redistribute either to areas where effort was concentrated previously, or as close to the new closure boundaries as possible) seem the most plausible. Many studies in other fisheries have shown that displaced fishing effort often concentrates near the borders of newly closed areas/marine protected areas [7-9].

The results in each table are color coded based on the assumption that the desired outcome of each closure is a reduction in sturgeon takes, and no change in flounder or shad catch rates. For each effort redistribution scenario column, the closure scenario with the most desirable outcome is highlighted in red, green, or blue (for sturgeon, flounder, or shad, respectively). These colors correspond to the color scheme used to represent catch per unit effort in Appendix A, figures 69, 70, and 71. The corridor expansion scenario with the least desirable outcome is highlighted in dark grey. The rest of the cells in each column are highlighted in varying shades of either red/green/blue or grey depending on where the cell's value falls on the range between the highest and lowest values in that column. Cells with no color fall near the middle of the range.

The results in these tables show that while it might initially seem beneficial to close an area based solely on the number of sturgeon takes that have historically occurred in an area (i.e. effort redistribution scenario 1), the redistribution of displaced effort may lead to unexpected results. For example, the prediction for scenario 1 in the spring months shows a 10% reduction in sturgeon catch (from 86 to 77 individuals) in closure area PL (Appendix A, table 1 & 2). However, once the cost of displaced effort being redistributed is taken into account, there is a 2%-13% predicted *increase* in sturgeon bycatch that results from closing that area (Appendix A, table 2).

The third type of table for each species in each season can be used in determining which closure scenario will result in the greatest reduction in sturgeon catch for smallest amount of forfeited fishing opportunity. For instance, the last closure scenario in the spring months in which all four areas are closed resulted in the largest decrease in sturgeon takes in all effort redistribution scenarios (Appendix A, table 1 & 2). It makes sense that this closure scenario would be the most effective at reducing sturgeon takes given the amount of area that it closes to fishing. However, this doesn't necessarily translate into being the most efficient management solution, since it would mean closing a huge portion of Albemarle Sound to gill netting. During spring for example, the most efficient management closure relative to total area closed and amount of effort displaced under effort redistribution scenario 3 would be LH (Lighthouse) although it does not result in the largest reduction in sturgeon bycatch (Appendix A, table 3). The most efficient closures vary by season (e.g. Appendix A, table 3 vs Appendix A, table 12).

It is important to point out that the true number of sturgeon takes in the commercial fishery within this region of Albemarle Sound is higher than presented as observers only attended a small percentage (≤10%) of commercial gill net trips taken during the time period examined.

The comparable tables for southern flounder (Appendix A, tables 4 & 5 for Spring) and American shad (Appendix A, tables 6 & 7 for Spring) could aid in deciding on the pros and cons of a potential closure in terms of the impact of closures on the catch rates of gill net target species.

4.3.5 SUMMARY

- The season-specific tables provided here can be used to determine which closed areas during which seasons will achieve a target reduction goal and in the most efficient way.
- To determine impacts on the gill net fishery, the forfeited catch of southern flounder and American shad are presented for season-specific closed areas.
- Due to the high degree of variability in predicted catch between effort redistribution scenarios, it may be useful to consult fishermen on how they predict effort would redistribute given certain closure scenarios.
- Sturgeon bycatch is highest during the spring; therefore the summary points below focus on results of the analysis for spring months under effort redistribution scenarios 3 and 4.
    - The closure scenario in the spring that results in the largest reduction of sturgeon takes is PL_B32_LH_BB, where all four of the closure areas closed to gill netting.
    - The single-area closure scenario in the spring that is the most efficient at reducing sturgeon bycatch is LH, and is also the most efficient of all closures (including multi-area closures) for effort redistribution scenario 3. In effort redistribution scenario 4, LH remains the most efficient single-area closure scenario.
    - Closure scenario PL is the least efficient single-area closure and results in a predicted increase in sturgeon takes. This is caused by displaced effort shifting into areas of high sturgeon CPUE just to the east of this closure.

4.4 HIGHER RESOLUTION MAPS OF TELEMETERED STURGEON IN THE CAPE FEAR & BRUNSWICK RIVERS

4.4.1 PURPOSE

The shad fishery in the Cape Fear and Brunswick Rivers could potentially pose a threat to Atlantic sturgeon through accidental takes at some point in the future. Monthly maps of cumulative sturgeon days were created to identify areas for potential time-area closures to mitigate this issue.

4.4.2 METHODS

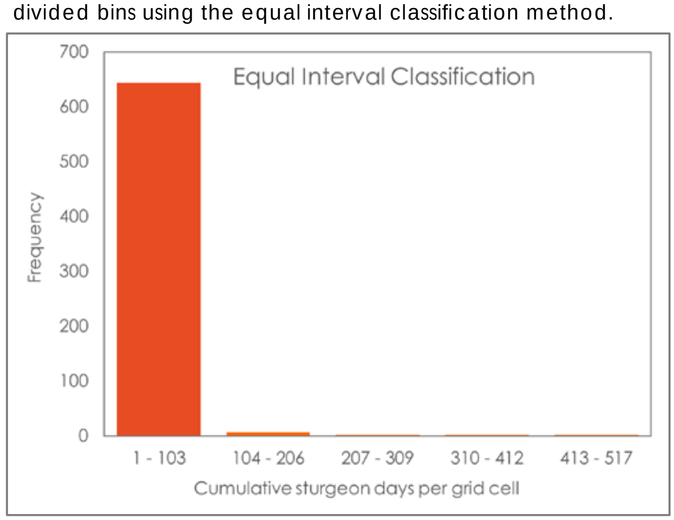
Maps were created using the same methods outlined in sections 4.1.1.3, 4.1.1.4, 4.1.1.6, and 4.1.1.7, with two differences:

1. The maps are higher resolution, using 0.5X0.5-mile grid as opposed to a 1X1-mile grid.
2. Three types of symbology classification methods were used:
    a. Equal interval
    b. Quantile
    c. Manual

4.4.2.1 EQUAL CLASSIFICATION

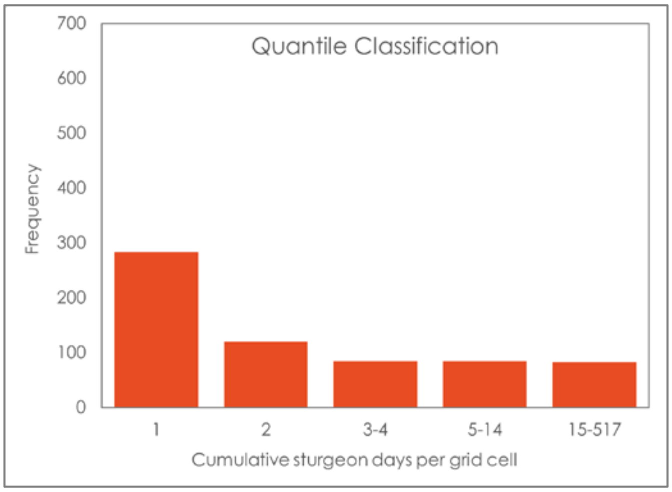
See section 4.1.1.4 for a description of this classification scheme. Figure 4.5 shows how the data from all months and all years of the Program 356 dataset in the Cape Fear and Brunswick Rivers is distributed within the equal interval classes.

Figure 4.5. Cumulative sturgeon days per month per grid cell divided bins using the equal interval classification method.



4.4.2.2 QUANTILE CLASSIFICATION

Figure 4.6. Cumulative sturgeon days per month per grid cell divided bins using the quantile classification method.

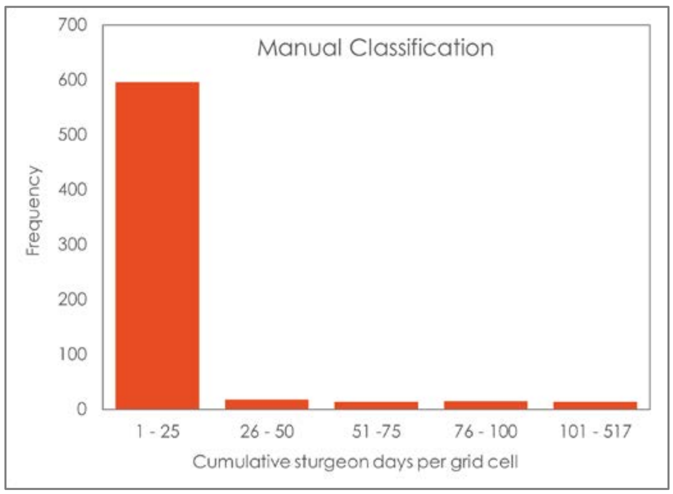


The quantile classification method divides the data into classes such that each class has an equal number of records (or as close to equal as possible). Figure 4.6 shows how the data from all months and all years of the Program 356 dataset in the Cape Fear and Brunswick Rivers is distributed within the quantile classes.

4.4.2.3 MANUAL CLASSIFICATION

The manual classification method was devised to accommodate the skewed distribution of the data while keeping most of the intervals equal in size to maximize ease of interpretation of the maps. Figure 4.7 shows how the data from all months and all years of the Program 356 dataset in the Cape Fear and Brunswick Rivers is distributed within the manually specified classes.

Figure 4.7. Cumulative sturgeon days per month per grid cell divided bins using the manual classification method.



4.4.3 FIGURES

- Equal interval classification map – Appendix A pg. 143
- Quantile classification map – Appendix A pg. 144
- Manual classification map – Appendix A pg. 145

4.4.4 RESULTS & DISCUSSION

Due to the highly skewed nature of this dataset (and all datasets considered in this report), it is hard to convey the spatial variations of values in the lower ranges of data using the equal classification scheme shown in Appendix A, figure 72. The quantile classification of the data (Appendix A, figure 73) does a better job at conveying variations in values at the low end of the range, however the resulting map is somewhat misleading because the range of values in each interval varies greatly. If one is trying to identify a time of year when the sturgeon residency in the Brunswick River peaks, Appendix A, figure 72, which uses an equal classification scheme, does not show a particular month or season as having a higher concentration of sturgeon. All grid cells in that area have a value within the range of 1 – 103 cumulative sturgeon days per month. Examination of the manual classification map (Appendix A, figure 74) reveals that there actually are higher concentrations of sturgeon in the Brunswick River during the summer months than there are during the rest of the year, with one grid cell containing 51-75 cumulative sturgeon days during those months, as opposed to a value within the range of 1-25 cumulative sturgeon days/month throughout the rest of the year. The equal classification map (Appendix A, figure 72) hides the finer scale variations in cumulative sturgeon day values.

The comparison of the three maps illustrates how the interpretation of a map can be affected by the classification methodology chosen. To be truly useful, managers should determine the class breaks that are significant for biological or management reasons when attempting to answer specific questions with the aid of these kinds of maps.

4.4.5 SUMMARY

- The highest cumulative sturgeon days values in the Cape Fear/Brunswick Rivers occur from April through November, and detections are much less frequent during the winter months.
- The highest cumulative sturgeon days values in the Brunswick River (where most of the shad fishing takes place) occur from May through August.
- Although telemetered sturgeon are detected in the Cape Fear River in all months of the year, there were only four sturgeon ever caught in the Cape Fear River in Program 915 between 2003 and 2014, and only one sturgeon caught in Program 466 between 2013 and 2014. Even when large numbers of telemetered sturgeon are being detected, there are very few sturgeon caught.
- There are currently no observer data records (Program 466) of the shad fishery in the Brunswick River.
- Increasing observer coverage of shad fishermen would aid in determining if there is a correlation between when telemetered sturgeon are detected and when they are being

caught in the shad fishery. Until these data are available, it may not be advisable to base decisions about closing the shad fishery on telemetry data.

4.5 STURGEON BYCATCH BY GEAR TYPE: FLOAT VERSUS SINK GILL NETS

4.5.1 PURPOSE

Observers in Program 466 documented two main types of gear: anchored gill nets (referred to as sink nets in this document) and floating anchored gill nets (referred to as float nets in this document). Program 466 data were analyzed to determine whether sturgeon were captured more frequently in one gear type than another in Pamlico and Albemarle Sounds.

4.5.2 METHODS

Observer data was compiled across all years for which data were available in each water body. These data were considered for each water body across all months, and then for the spring months (February – April) alone. Statistics on the occurrence of sturgeon bycatch were calculated, and point maps of sturgeon bycatch were plotted for float nets and sink nets.

4.5.3 FIGURES

4.5.3.1 TABLES

- Albemarle Sound, All Months – Appendix A pg. 146
- Albemarle Sound, Spring Months (Feb – Apr) – Appendix A pg. 153
- Pamlico Sound, All Months – Appendix A pg. 160
- Pamlico Sound, Spring Months (Feb – Apr) – Appendix A pg. 163

4.5.3.2 MAPS

- Albemarle Sound, All Months – Appendix A pg. 147
- Albemarle Sound, Spring Months (Feb – Apr) – Appendix A pg. 154
- Pamlico Sound, All Months – Appendix A pgs. 161
- Pamlico Sound, Spring Months (Feb – Apr) – Appendix A pg. 164

4.5.4 SUMMARY

- More sink nets than float nets were observed in both water bodies in both time periods.
- More sturgeon bycatch was observed in both gear types in Albemarle Sound than in Pamlico Sound in both time periods
- Both the total sturgeon bycatch per unit effort and the percent of records with sturgeon bycatch were higher in float nets than in sink nets in the Albemarle sound for both time

periods (Appendix A, tables 25 and 26). This difference was not tested for statistical significance, and the percent of records with sturgeon bycatch was only 3% higher for float nets than sink nets for both time periods.

- The total sturgeon bycatch per unit effort and the percent of records with sturgeon bycatch were higher in sink nets than in float nets in the Pamlico sound when all months were considered (Appendix A, table 27), though this trend reversed in the spring months (Appendix A, table 28). This difference was not tested for statistical significance, and the percent of records with sturgeon bycatch only differed by 1% between float and sink nets in both time periods.

5. Sea Turtle Bycatch and Distribution

5.1. BACKGROUND

The southern flounder fishery is the most economically important estuarine finfish fishery in North Carolina [10]. A large portion of this species' landings is caught using large-mesh gill nets, a gear-type known to have high rates of sea turtle bycatch [11]. The North Carolina Division of Marine Fisheries (DMF) has implemented various adaptive management measures since 1999 to reduce sea turtle bycatch in large-mesh gill nets in the Pamlico Sound, where the largest portion of NC southern flounder are caught [4, 10, 11]. Since 2000, the deep-water portions of the Pamlico Sound as well as three inlet corridors into the sound have been closed to large-mesh gill nets during the southern flounder fishing season (September - December) in order to reduce the number of interactions between the fishery and sea turtles [12]. In past years the fishing season has often been closed or shortened in order to stay below authorized sea turtle incidental take levels, causing fishermen to forego a significant source of income [11]. Managers at DMF want to determine if expanding the area closed to fishing around the Pamlico Sound inlet corridors could be an effective way of reducing sea turtle bycatch in the flounder fishery, thereby allowing the fishery to operate more days of the year.

Due to the high number of interactions between the southern flounder gill net fishery and endangered sea turtles on the Pamlico Sound, DMF has had to apply for an Incidental Take Permit (ITP) under the Endangered Species Act and implement management measures to reduce sea turtle takes since the year 2000. As part of the management plan implemented under the ITP, DMF closes the deep water portions of the Pamlico Sound to gill netting each year from September to December, and has established an observer program (DMF Program 466) with a goal of 10% observer coverage of the large mesh gill net fishery during the flounder season [3]. The areas of the Pamlico Sound near the Outer Banks that are open to gill netting from September to December each year are referred to as the Shallow Water Gill Net Restricted Areas (SWGNRAs; figure 5.1).

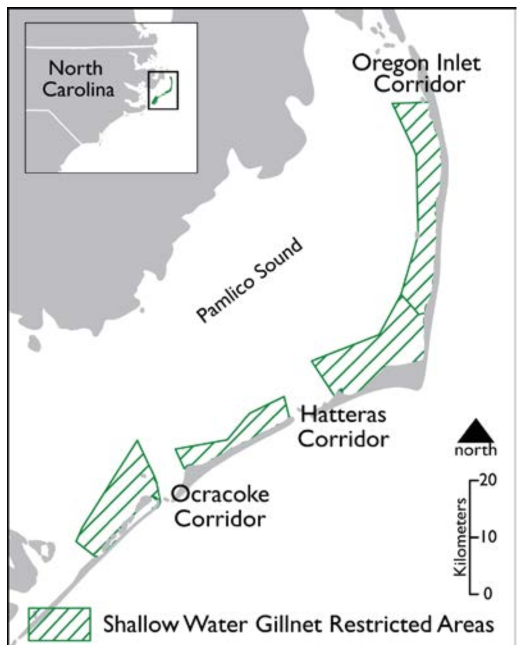


Figure 5.1. Areas where gillnetting is allowed from September to December

Program 466 uses a fishery-dependent sampling design, in which observers go out with commercial, large and small mesh gill net fishermen and record the location, catch, and gear used

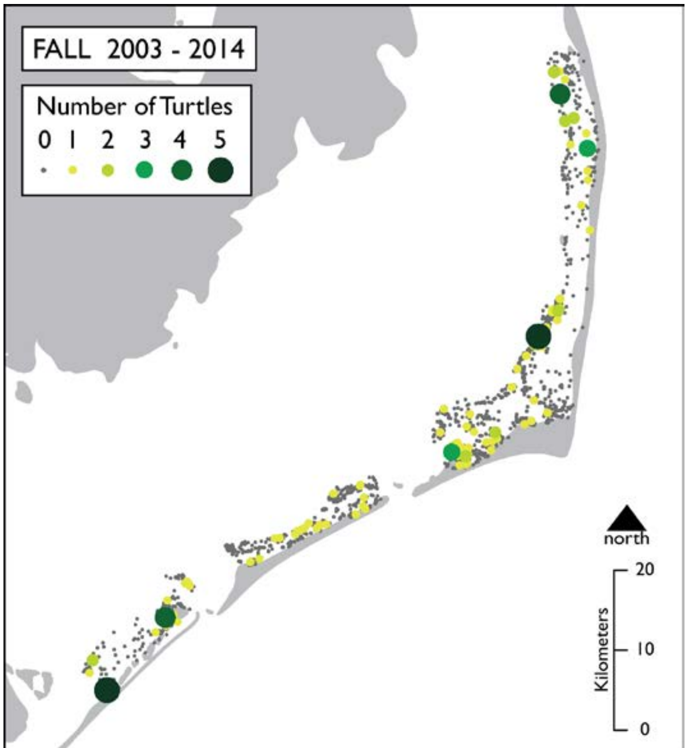


Figure 5.2. Sea turtle bycatch in the southern flounder large-mesh gill net fishery from September to December, 2003 to 2013. Co--ordinates are recorded by fishery observers. For this study, we used only records within the shallow water gill net areas.

along with many environmental variables. For this study, we used data collected by observers between 2003 and 2014, during the months of September through December. To prepare this dataset for use in our analysis, all records collected at locations outside of the SWGNRAs were discarded. Due to the relatively small size of the dataset and number of observed sea turtle interactions, we did not distinguish between the three sea turtle species observed in this fishery (green, Kemps ridley, and loggerhead). We deleted records where it appeared there had been data entry errors, for instance if the coordinates were on land, or if records had net lengths greater than 3000 yards/soak times greater than 3 days. We were left with 1945 records (fishing events), and 121 sea turtle takes (figure 5.2). Net lengths and soak times averaged around 1000 yards and 1 day, respectively.

5.2. MONTHLY, SEASONAL, AND ANNUAL ANALYSIS

This section of the report is intended to support decisions regarding the management of sea turtles and southern flounder in the Shallow Water Gill Net Restricted Areas (SWGNRAs) in Pamlico Sound at monthly and seasonal temporal resolution. Specifically, these tables and charts could be used to determine the impact of inlet corridor expansions on sea turtle bycatch and southern flounder catch rates.

5.2.1 METHODS

5.2.1.1 MAPS

5.2.1.1.1 Map Types and Parameters

To determine whether sea turtle takes were occurring near the inlet corridors, two general types of maps were created: point maps and grid maps. On the point maps, the parameter's value is shown at the latitude/longitude coordinate where the fishing event took place. On the grid maps, the value of the relevant parameter was summed up for all records within 2000X2000 yard grid cells over a given time step. Grid cells within the SWGNRAs that did not contain any records from the Program 466 dataset were removed from the map.

The parameters displayed on these maps are:

1. Number of sea turtles
    a. Point maps - display the number of sea turtles caught during each fishing event over a given time period.
    b. Grid maps - display the number of sea turtles caught within a grid cell over a given time period.

2. Fishing effort
    c. Grid maps - display fishing effort summed up across all points within a grid over a given time period. Fishing effort was calculated as the product of net length (yards) and the amount of time gear was fished (days) at each location.

3. Bycatch per unit effort (BPUE)
    d. Grid maps - display the number of sea turtles caught per unit of effort. BPUE is calculated as the sum of all sea turtles caught divided by the sum of all effort within a grid cell over a given time period. These maps are essentially created by dividing the number of sea turtle maps by the effort maps.

5.2.1.1.2 Map Symbology

For all three parameters (number of sea turtles, fishing effort, and sea turtle BPUE) the data are heavily skewed, with the largest portion of values falling at the low end of the range (at or close to zero). Although it would be preferable to display each parameter by dividing the range of values into equal intervals, representing the data in this way would hide some of the variations in values at the lower end of the range, and make it difficult to identify areas with values higher than the mean/median value of the parameter. A manual classification scheme was devised to best convey the finer scale differences in values at the bottom of the range for each parameter.

5.2.1.1.3 Temporal Resolution

We created maps of the Program 466 data for the months that the southern flounder fishery operates in the SWGNRAs: from September through December, which is referred to as “fall” in all figures. We also created maps for each individual month during the southern flounder season – September, October, and November. No maps were made for the month of December alone due to the low number of observations and lack of sea turtle interactions during this month. Due to inter-annual variability in catch and effort, we created fall and monthly maps using data from 3-year intervals (2003 – 2005, 2006 – 2008, 2009 – 2011, and 2012 – 2014) in addition to maps created from the full dataset (2003 – 2014).

5.2.1.2 PREDICTING THE EFFECT OF EXPANDING PAMLICO SOUND INLET CORRIDORS ON CATCH OF SEA TURTLES AND SOUTHERN FLOUNDER

5.2.1.2.1 Selecting New Corridor boundaries

We used the grid maps to identify spatial and temporal clusters of high BPUE values near existing corridor boundaries. The locations of the expanded corridor boundary lines were then selected based the location of these clusters and proximity to geographic markers, such as bays, points, and islands. This was done to increase the ease of enforceability of the new boundaries.

5.2.1.2.2 Calculating Fishing Effort Redistribution

We explored the effect of expanding the corridors boundaries on the number of sea turtle takes and southern flounder catch. We calculated the percent change in sea turtle bycatch and southern flounder catch assuming that all effort in the expanded inlet corridors would not have occurred within those boundaries from 2003 – 2014 under different scenarios of redistribution of fishing effort. New effort under each effort redistribution scenario was calculated at each individual fishing site (latitude/longitude coordinate), and new turtle/flounder catch estimates were calculated by multiplying the new effort by the original catch per unit effort estimates. In this modeling exercise, we assumed that displaced effort would only be reallocated to fishing sites within the same SWGNRA.

5.2.1.2.3 Effort Redistribution Scenarios

1. No redistribution: All displaced effort is eliminated completely, e.g. all effort that occurred within in the proposed expanded corridor boundaries is removed and not reallocated to other fishing sites.
2. Even redistribution: All displaced effort is shifted into areas where fishing is allowed within the affected SWGNRA, and is redistributed evenly across known fishing sites.
3. Proportional redistribution: All displaced effort is shifted into areas where fishing is allowed within the affected SWGNRA, and is redistributed across known fishing sites proportionally to recorded effort in that location (i.e. sites with high effort would get allocated a larger percentage of displaced effort).
4. Inverse distance weighted redistribution: All displaced effort is shifted into areas where fishing is allowed within the affected SWGNRA, and is redistributed across known fishing sites in an inverse distance weighted manner within 15 km of the new closed area boundaries (i.e. more of the effort is reallocated to fishing sites near the closed areas).

5.2.1.2.4 Temporal Resolution

We conducted the analysis over the months that the southern flounder fishery operates in the SWGNRA – from September through December, referred to as "fall" in all figures. We also conducted the analysis for individual months during the southern flounder season – September, October, and November. December was excluded from the individual monthly analysis due to the low number of observations and lack of sea turtle interactions during this month.

5.2.1.3 GETIS–ORD GI* HOTSPOT ANALYSIS

Due to the ambiguity introduced into the analysis by the selection of the search radius *d* (see equation 1), the Getis-Ord Gi* hot spot analysis was not used as a basis for determining corridor expansions, but we have included a description of the technique here for reference. We also discuss some of the drawbacks of this technique in section 5.2.2.3, as hot spot analysis is often used in the spatial analysis of fisheries data [13-15].

The tool *Hot Spot Analysis (Getis-Ord Gi*)* from the Spatial Analyst toolbox in ArcMap can be used to identify statistically significant clusters (e.g. hot spots) of sea turtle bycatch. This tool calculates the Getis-Ord Gi* statistic for each feature in a dataset. In our case the features are gill net hauls observed as part of Program 466, and the value in question is sea turtle BPUE at each fishing site.

$$G_i^*(d) = \frac{\sum_{j=1}^{n} W_{ij}(d) x_j}{\sum_{j=1}^{n} x_j}$$

Equation 4. Getis-Ord Gi statistic, Where xj is the BPUE value for each point location j, Wij(d) is the spatial weight between feature I and all features j within the specified search radius d, and n is the total number of features.*

For each feature (j), the statistic compares the average BPUE across all other features within a specified search radius (*d*) around the feature in question to the average BPUE across all fishing records across the entire study area (SWGNRAs 1 through 4). The results are then converted to z-scores to determine statistical significance [16]. For more information on the Getis-Ord Gi* statistic and tool please see - Ord, J. K. and A. Getis (1995) and the ArcGIS Desktop Help webpage[3] for this tool.

[3] http://desktop.arcgis.com/en/desktop/latest/tools/spatial-statistics-toolbox/hot-spot-analysis.htm

5.2.2 RESULTS & DISCUSSION

5.2.2.1 MAPS

The maps created using the methodology described in section 5.2.1.1 are contained in Appendix B, pages 167– 188. Effort and sea turtle bycatch shift throughout the season and as well as vary from year to year. Clusters of high bycatch per unit effort values tend to occur near Hatteras Island, as well as south of Oregon Inlet and behind Portsmouth Island (southwest of the Ocracoke Corridor).

Figures 5.3 – 5.5 below show the distribution of the program 466 data, divided into the bins used to display these data on the maps.

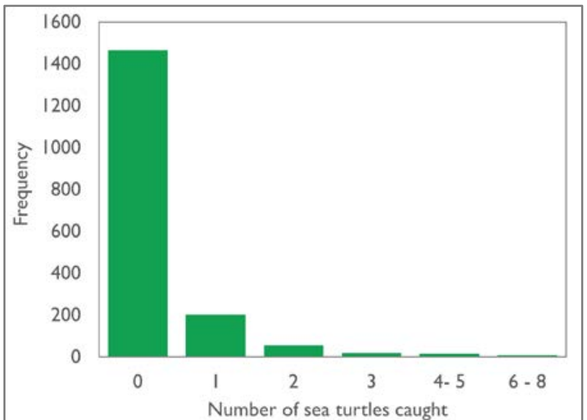


Figure 5.3. Frequency distribution of the number of sea turtles caught per grid cell on all maps in appendices A and B. Data are divided using the same classes displayed on the maps.

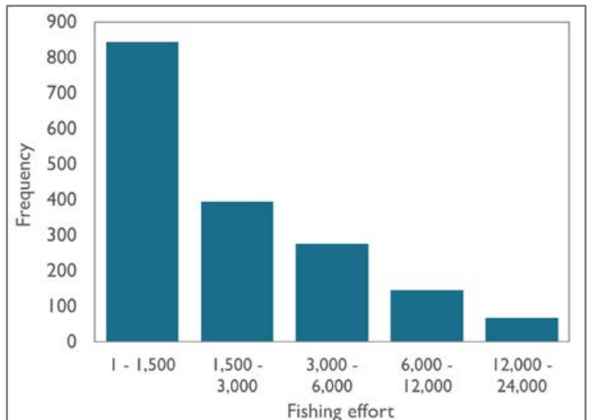


Figure 5.4. Frequency distribution of total fishing effort per grid cell on all maps in appendices A and B. Data are divided using the same classes displayed on the maps.

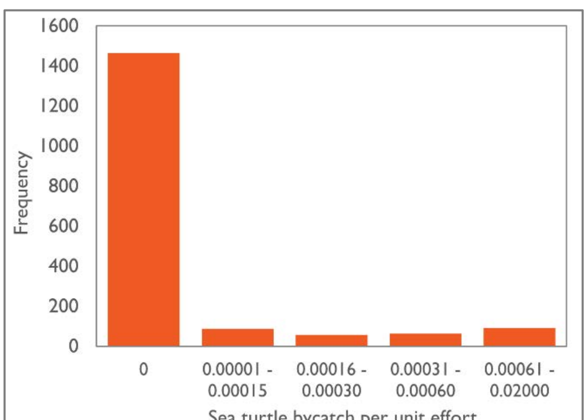


Figure 5.5. Frequency distribution of sea turtle bycatch per unity effort per grid cell on all maps in appendices A and B. Data are divided using the same classes displayed on the maps.

5.2.2.2 PREDICTING THE EFFECT OF EXPANDING PAMLICO SOUND INLET CORRIDORS ON CATCH OF SEA TURTLES & SOUTHERN FLOUNDER

5.2.2.2.1 Proposed Corridor Expansions

Based on the clusters of high BPUE values shown on Appendix B, figures 9 – 12, we decided to analyze the effect of:

1. Expanding Oregon Inlet Corridor to the south.
2. Expanding Hatteras Corridor to the northeast.
3. Expanding Ocracoke Corridor to the southwest.

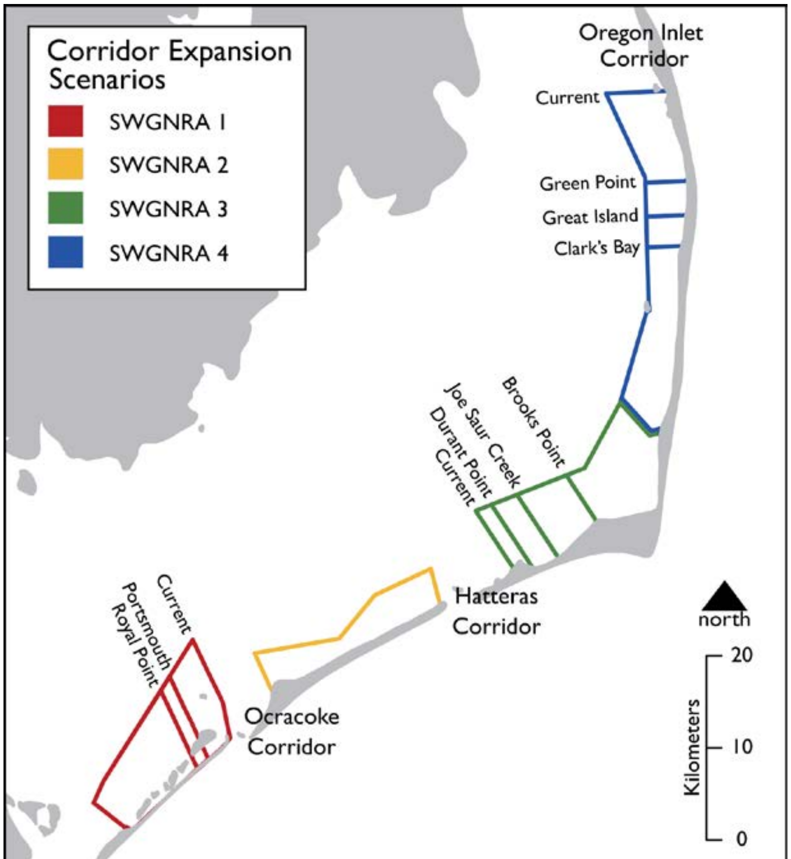


Figure 5.6. Proposed boundaries of expanded inlet corridors into Pamlico Sound.

Geographic markers were then selected to delineate new corridor boundary lines, such that portions of the high BPUE value areas near the inlet corridors would be included in the expanded corridors. Multiple potential boundary lines were chosen for each expansion scenario. Table 5.1 contains a list of the geographic markers (and coordinates) selected to delineate the expanded corridor boundary lines for each of the proposed corridor expansions, which are also shown on figure 5.6. The new boundary lines start at the geographic marker and extend to the outer edge (towards mainland) of the SWGNRA, parallel to the current boundary line.

Table 5.1. Corridor expansion scenario names, geographic markers, and coordinates.				
Corridor	**Scenario Name**	**Geographic Marker**	**Latitude**	**Longitude**
Oregon Inlet Corridor	Oreg_Green	Green Point	35.597	-75.472
	Oreg_Great	Great Island	35.531	-75.482
	Oreg_Clarks	Clark's Bay	35.531	-75.482
Hatteras Corridor	Hatt_Durant	Durant Point	35.233	-75.681
	Hatt_JoeSaur	Joe Saur Creek	35.229	-75.639
	Hatt_Brooks	Brooks Point	35.269	-75.596
Ocracoke Corridor	Ocra_Portsmouth	Portsmouth Island/Evergreen Slough	35.069	-76.076
	Ocra_Royal	Royal Point	35.053	-76.088

The potential corridor expansion boundaries shown in figure 5.6 were overlaid on maps of sea turtle BPUE and southern flounder catch per unit effort (Appendix B, figures 33 & 34). The southern flounder maps were created using the same methodology as is described in section 5.2.1.1 for sea turtles.

5.2.2.2.2 Corridor Expansion's Effect on Sea Turtle & Flounder Catch Estimates

The results of the effort redistribution analysis are contained in a series of tables in Appendix B, pages 192 – 211. There are three types of tables. The first two types were created for both sea turtles and flounder:

1. Table type 1 shows the absolute (number of individuals) change in catch in each of the different effort redistribution scenarios (columns) described in section 5.2.1.2.3, for each of the different corridor expansion scenarios (rows) shown in figure 5.6.
2. Table type 2 shows the relative (percent) change in catch in each of the different effort redistribution scenarios (columns) described in section 5.2.1.2.3, for each of the different corridor expansion scenarios (rows) shown in figure 5.6.

The third type of table was created only for sea turtles:

3. Table type 3 quantifies the efficiency of each corridor expansion scenario in terms of the reduction in sea turtle takes relative to the amount of area closed to fishing, the amount of effort displaced, and the change in southern flounder catch. Only the results of effort redistribution scenarios 3 and 4 are displayed because these are "worst case" scenarios (meaning that pre- and post-corridor expansion effort remains the same), and the assumptions in these scenarios (that effort would redistribute either to areas where effort was concentrated previously, or as close to the new corridor boundaries as possible) seem

the most plausible. Many studies in other fisheries have shown that displaced fishing effort often concentrates near the borders of newly closed areas/marine protected areas [7-9].

The results in each table are color coded based on the assumption that the desired outcome of expanding the inlet corridors is a reduction in sea turtle takes, and no change in southern flounder catch rates. For each effort redistribution scenario column, the corridor expansion scenario with the most desirable outcome is highlighted in red or purple (for sea turtles and southern flounder, respectively). These colors correspond to the color scheme used to represent BPUE in Appendix B, figures 33 and 34. The corridor expansion scenario with the least desirable outcome is highlighted in dark grey. The rest of the cells in each column are highlighted in varying shades of either red/purple or grey depending on where the cell's value falls on the range between the highest and lowest values in that column. Cells with no color fall near the middle of the range.

The results in these tables show that while it might initially seem beneficial to close an area based solely on the number of sea turtle takes that have historically occurred in an area (i.e. effort redistribution scenario 1), the redistribution of displaced effort may lead to different results. For example, the prediction for effort redistribution scenario 1 in the fall shows a 25.6% reduction in sea turtle takes in corridor expansion scenario Hatt_Brooks (Appendix B, tables 2 and 3). However, once the cost of redistributing displaced effort is taken into account, there is either a much smaller reduction (9.1%) or anywhere from a 9.1 – 16.5% predicted *increase* in sea turtle bycatch that results from closing that area, depending on the effort redistribution scenario (Appendix B, table 3).

The third type of table for each species in each season can be used in determining which corridor expansion scenario will result in the greatest reduction in sea turtle catch for smallest amount of forfeited fishing opportunity. For instance, corridor expansion scenario Oreg_Clarks resulted in the largest decrease in sea turtle takes under effort redistribution scenarios 3 and 4 in the fall (Appendix B, table 4). It makes sense that this corridor expansion scenario would be the most effective at reducing sea turtle takes given that it is the scenario with the most additional area closed to gill netting (86 square km; Appendix B, table 4). However, this doesn't necessarily translate into being the best or most efficient management solution, since it would mean closing a large portion of the SWGNRA 4 to gill netting. The most efficient corridor expansion scenario (when considering all three ratios under both effort redistribution scenarios 3 and 4) is Oreg_Great, even though this expansion doesn't result in the largest reduction in sea turtle bycatch (Appendix B, table 4).

These tables reveal that it would be a more effective management solution to only close certain corridors for a portion of the season. The greatest reduction in sea turtles that results from expanding any corridor for the entire length of the southern flounder season would only save between a maximum of 13 or 15 sea turtles (Oreg_Great & Oreg_Clark) in either the 3rd or 4th effort redistribution scenarios (Appendix B, table 4). Alternatively, expanding the Hatteras Corridor to the Brooks Point boundary line (Hatt_Brooks) for just the month of September leads to a predicted reduction in the number of sea turtle takes by 17 or 18 in scenarios 3 and 4, respectively (Appendix B, table 9). Additionally, the Hatt_Brooks corridor expansion scenario in September also has a high number of sea turtles caught relative to the change in flounder catch (last two columns of Appendix B, table 9), with only a 2% increase in the number of flounder caught (Appendix B, table 11).

The table types 1 and 2 for southern flounder could aid in deciding on the pros and cons of a corridor expansion in terms of the impact of each corridor expansion scenario on catch rates of southern flounder. There is predicted to be a relatively small change in the amount of southern flounder caught in effort redistribution scenarios 3 and 4 for all proposed boundaries and for all months. In most scenarios, the predicted change is within the range of 1 to 3%, with a maximum change of an 8.7% decrease in southern flounder catch occurring for the Hatt_Brooks corridor expansion in effort redistribution scenario 4 in November (Appendix B, table 24).

It is important to point out that the true number of sea turtle takes and southern flounder catch in the commercial fishery within the SWGNRAs is higher than presented in these tables, as observers only attended a small percentage (7-10%) of commercial gill net trips taken during the time period examined.

5.2.2.3 GETIS–ORD GI* HOTSPOT ANALYSIS

As mentioned in section 5.2.1.3, the Getis-Ord Gi* hot spot analysis was not used to determine which corridors to expand. The main reason for deciding against this technique was the ambiguity introduced into the results when specifying the search radius *d*. For example, a small search radius would include fewer points in each calculation, e.g. only the fishing locations within a very close proximity to the feature in question. This could result the designation of hotspots only in areas where high BPUE values are very tightly clustered, and overlook areas that have equally high BPUE values that are more dispersed, but may still be important for management purposes. There is little guidance in the literature regarding the selection of an appropriate search radius. It has been suggested that the search radius be specified based on knowledge of the system being studied and the underlying spatial processes, however the decision is ultimately subjective [17].

Figure 5.7 illustrates how changing the search radius *d* can significantly impact the location of identified hot spots. At smaller search radii (*d* =1000m or 2000m) there appear to be many statistically significant clusters of high BPUE values. Of particular significance (because it is close to an inlet corridor) is the hotspot to the northeast of the Hatteras Corridor. This hotspot then disappears when larger search radii are used (*d* >4000m). In addition to affecting the location of hot spots, the selection of the search radius also affects the size and level of confidence with which this technique predicts each hot spot.

There have been alternative techniques suggested for the identification of hot spots that are less susceptible to the issue described above. One such technique was developed by Bartolino et. al (2011), and uses cumulative relative frequency distribution curves to identify hot spots, and should be more objective than the Getis-Ord Gi* statistic [17-19].

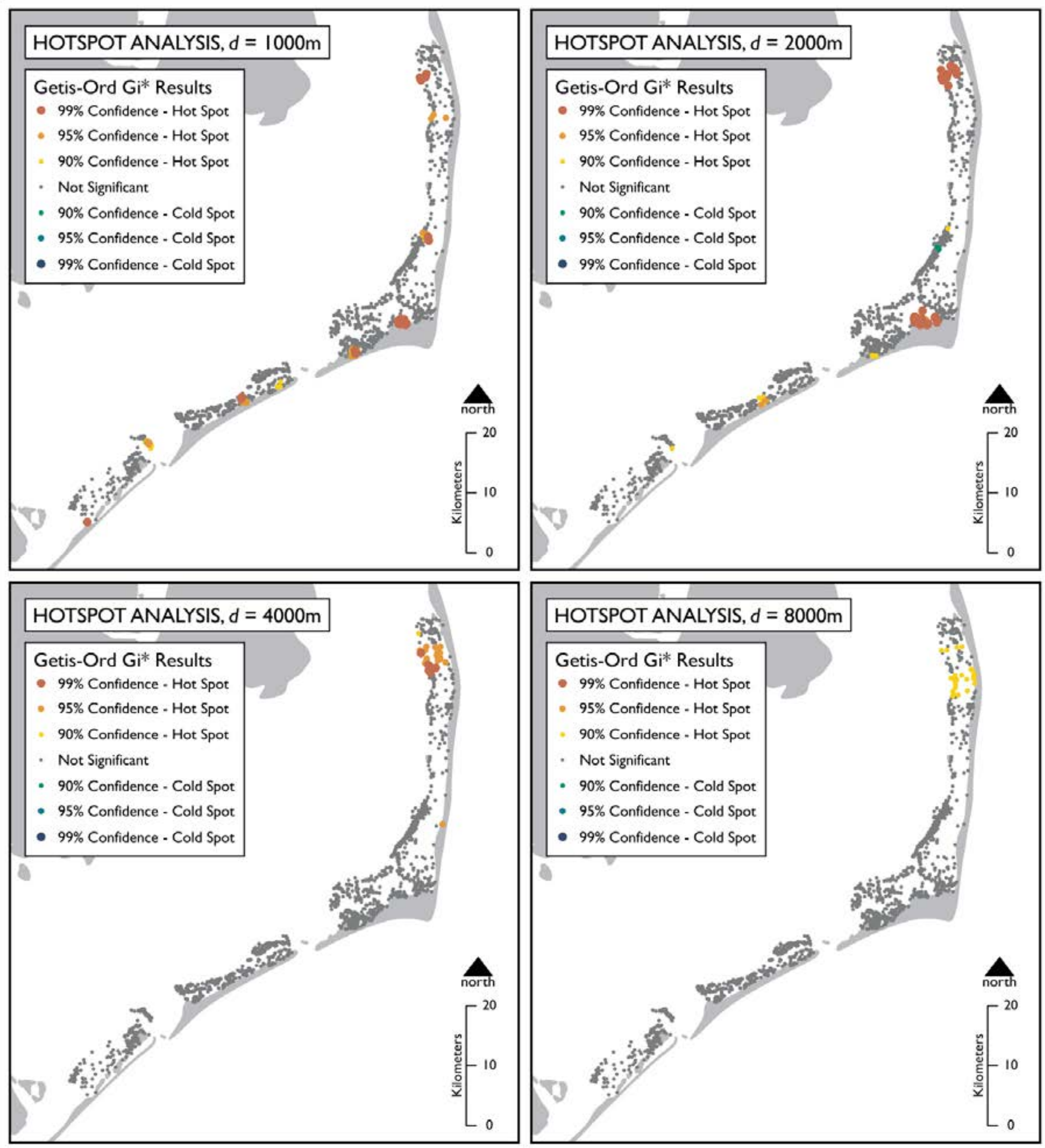


Figure 5.7. Results of the Getis-Ord Gi* Hot Spot analysis from September through December using varying distances for the search radius *d*. Results are expressed in percent confidence that locations are a hot spot or cold spot.

5.2.3 SUMMARY

- Based on data collected by observers in DMF Program 466, there do appear to be areas of high sea turtle bycatch located within the SWGNRAs, near the Pamlico Sound inlet corridors.
- Although Getis-Ord Gi* hotspot analysis is commonly used in analyzing environmental and fisheries spatial data, the subjectivity of this type of analysis led us to base the delineation of new inlet corridor boundaries solely on visual inspection of BPUE maps.

- Simulating effort redistribution under different scenarios of inlet corridor expansion revealed that this could be an effective way of reducing sea turtle bycatch in the southern flounder large-mesh gill net fishery without heavily impacting current catch rates of southern flounder.
- Expanding the corridors for just September is more effective at reducing sea turtle takes in most scenarios than expanding the corridors for the entire fall.

5.3 BI-WEEKLY ANALYSIS

This section of the report is intended to support decisions regarding the management of sea turtles and southern flounder in the Shallow Water Gill Net Restricted Areas (SWGNRAs) in Pamlico Sound on a finer temporal scale. Specifically, these tables and charts could be used to determine the impact of 1) inlet corridor expansions and 2) the opening and closing dates of the southern flounder fishing season, on sea turtle bycatch and southern flounder catch rates.

5.3.1 METHODS

5.3.1.1 MAPS

5.3.1.1.1 Map Types, Parameters, and Symbology

Maps were created using the methods outlined in sections 5.2.1.1.1 and 5.2.1.1.2

5.3.1.1.2 Temporal Resolution

We created maps over the time period that the southern flounder fishery operates in the SWGNRA and has encountered sea turtles: from September through November. This overall period was divided into six biweekly periods (BWP). These periods are

- BWP1: 9/1 to 9/14
- BWP2: 9/15 to 9/28
- BWP3: 9/29 to 10/12
- BWP4: 10/13 to 10/26
- BWP5: 10/27 to 11/9
- BWP6: 11/10 to 11/23

The last week of November was excluded from this supplementary report due to low effort and lack of sea turtle bycatch.

5.3.1.2 GRAPHS OF TEMPERATURE, DAY OF YEAR, AND SEA TURTLE BYCATCH

Graphs of sea turtle bycatch, water temperature, and day of year were plotted to examine the relationship between these three parameters. Only records where observers had recorded water temperature were used in this analysis (896 out of 1945 records). Observers collected surface and bottom water temperatures. Surface temperature was used in this analysis except in cases where only bottom temperature was recorded, in which case bottom temperature was used instead.

5.3.1.3 PREDICTING THE EFFECT OF EXPANDING PAMLICO SOUND INLET CORRIDORS ON CATCH OF SEA TURTLES & SOUTHERN FLOUNDER

5.3.1.3.1 Calculating Fishing Effort Redistribution

We explored the effect of expanding the areas closed to gill netting around inlet corridors into Pamlico Sound on the number of sea turtle takes and southern flounder catch. We calculated the percent change in sea turtle bycatch and southern flounder catch assuming that all effort in the expanded inlet corridors would not have occurred within those boundaries from 2003 – 2014 under different scenarios of redistribution of fishing effort. New effort under each effort redistribution scenario was calculated at each individual fishing site (latitude/longitude coordinate), and new turtle/flounder catch estimates were calculated by multiplying the new effort by the original catch per unit effort estimates. In this modeling exercise, we assumed that displaced effort would only be reallocated to fishing sites within the same SWGNRA.

5.3.1.3.2 Effort Redistribution Scenarios

1. No redistribution: All displaced effort is eliminated completely, e.g. all effort that occurred within the proposed expanded corridor boundaries is removed and not reallocated to other fishing sites.
2. Even redistribution: All displaced effort is shifted into areas where fishing is allowed within the affected SWGNRA, and is redistributed evenly across known fishing sites.
3. Proportional redistribution: All displaced effort is shifted into areas where fishing is allowed within the affected SWGNRA, and is redistributed across known fishing sites proportionally to recorded effort in that location (i.e. sites with high effort would get allocated a larger percentage of displaced effort).
4. CPUE redistribution: All displaced effort is shifted into areas where fishing is allowed within the affected SWGNRA, and is redistributed across known fishing sites proportionally to recorded flounder catch per unit effort in that location (i.e. sites with high flounder CPUE would get allocated a larger percentage of displaced effort).
5. Inverse distance weighted redistribution: All displaced effort is shifted into areas where fishing is allowed within the affected SWGNRA, and is redistributed across known fishing sites in an inverse distance weighted manner within 15 km of the new closed area boundaries (i.e. more of the effort is reallocated to fishing sites near the closed areas).

5.3.1.3.3 Temporal Resolution

We conducted the analysis over the time period that the southern flounder fishery operates in the SWGNRA and has encountered sea turtles: from September through November. The analysis results are divided into six biweekly periods (BWP). These periods are

- BWP1: 9/1 to 9/14
- BWP2: 9/15 to 9/28
- BWP3: 9/29 to 10/12
- BWP4: 10/13 to 10/26
- BWP5: 10/27 to 11/9
- BWP6: 11/10 to 11/23

The last week of November was excluded from this supplementary report due to low effort and lack of sea turtle bycatch.

5.3.2 RESULTS & DISCUSSION

5.3.2.1 SEA TURTLE & FLOUNDER CATCH RATES FROM 2003 - 2014

Sea turtle bycatch per unit effort fluctuates more than flounder catch per unit effort throughout the flounder fishing season (Appendix B, figure 35). Sea turtle BPUE peaks in BWP1, BWP4, and BWP5, whereas southern flounder CPUE stays relatively constant throughout the first 4 BWPs, and starts to decline in the last two BWPs. The absolute number of sea turtles caught in BWP1 is the second lowest for any time period (Appendix B, figure 36), but sea turtle BPUE is at its highest during this period (Appendix B, figure 35). Effort is relatively low during this time period, which is partially caused by later flounder season start dates in more recent years (Appendix B, figure 37 and table 22).

Note: All but one of the sea turtles caught in BWP1 were caught during just two years: 2008 and 2009. Over the course of the program, the highest number of observed September trips occurred during these two years (Appendix B, figure 37).

5.3.2.2 TEMPERATURE, DAY OF YEAR, AND SEA TURTLE BYCATCH

Observers recorded a total of 58 sea turtles on hauls where temperature was also recorded. Hauls were observed between September 1st and December 22nd. October had the highest proportion of observed hauls, as well as the highest proportion of sea turtle bycatch (44.64% and 43.10%, respectively; Appendix B, figures 45, 49). Recorded temperatures ranged between 2 and 39 degrees Celsius, and 76% of observed hauls occurred between 15-25 degrees Celsius (Appendix B, figures 46, 47, 51, 52). Recorded temperatures for just the hauls with sea turtle bycatch ranged between 11 and 28 degrees Celsius, and 84% of observed sea turtles were caught between 15-25 degrees Celsius.

The highest rates of sea turtle bycatch per unit coincide with temperatures between 28 and 30 degrees Celsius (Appendix B, figure 52). The highest absolute numbers of sea turtle bycatch occur between 26 and 20 degrees Celsius, coinciding with increased effort during that period (Appendix B, figure 51). The highest rates of bycatch per unit effort and absolute bycatch occurred between days 260 and 265 (Appendix B, figures 49 and 50). Between days 260 and 265 the average temperature across 54 hauls observed in this period was 23 degrees Celsius (Appendix B, figure 48).

5.3.2.3 PROPOSED CORRIDOR EXPANSIONS

We analyzed the effect of:

1. Expanding Oregon Inlet Corridor to the south.
2. Expanding Hatteras Corridor to the northeast.
3. Expanding Ocracoke Corridor to the southwest.

Geographic markers were then selected to delineate new corridor boundary lines, such that high BPUE areas near the inlet corridors would be included in the expanded corridors. Multiple potential boundary lines were chosen for each expansion scenario. Appendix B, table 23 contains a list of the geographic markers (and coordinates) selected to delineate the expanded corridor boundary lines for each of the proposed corridor expansions, which are also shown in Appendix B, figure 38. The new boundary lines start at the geographic marker and extend to the outer edge (towards mainland) of the SWGNRA, parallel to the current boundary line.

5.3.2.4 HOW TO READ THE TABLES

Appendix B, tables 25 and 26 show the amount of fishing effort under each of the corridor expansion scenarios, and the percent change in fishing effort if displaced effort was not redistributed after the expansion (i.e. effort redistribution scenario 1).

The predicted impact of the corridor expansions and effort redistribution scenarios on sea turtle bycatch and flounder catch are contained in a series of tables (Appendix B, tables 26 – 49). There are 4 types of tables.

- Table type 1 shows the ***absolute*** (number of individuals) predicted sea turtle ***bycatch or flounder catch*** in each of the different effort redistribution scenarios (columns) described in section 5.3.1.3.2, for each of the different corridor expansion scenarios (rows) shown in Appendix B, figure 38. These are even numbered tables in Appendix B, between pages 222 and 233.
- Table type 2 shows the ***relative*** (percent) change in predicted sea turtle ***bycatch or flounder catch*** in each of the different effort redistribution scenarios (columns) described

in section 5.3.1.3.2, for each of the different corridor expansion scenarios (rows) shown in Appendix B, figure 38. These are odd numbered tables in Appendix B, between pages 222 and 233.

The results in each table are color coded based on the assumption that the desired outcome of expanding the inlet corridors is a reduction in both sea turtle takes and southern flounder catch. For each effort redistribution scenario column, the corridor expansion scenario with the most desirable outcome is highlighted in green or purple (for sea turtles and southern flounder, respectively). The corridor expansion scenario with the least desirable outcome is highlighted in dark grey. The rest of the cells in each column are highlighted in varying shades of either green/purple or grey depending on where the cell's value falls on the range between the highest and lowest values in that column. Cells with no color fall near the middle of the range.

It is important to point out that the true number of sea turtle takes and southern flounder catch in the commercial fishery within the SWGNRAs is higher than presented in these tables, as observers only attended a small percentage (7-10%) of commercial gill net trips taken during the time period examined.

5.3.2.5 PREDICTED SEA TURTLE & FLOUNDER CATCH RATES UNDER DIFFERENT CORRIDOR EXPANSION AND EFFORT REDISTRIBUTION SCENARIOS

Below is a summary of the predicted impact of expanding the areas closed to gill netting around the inlet corridors into Pamlico Sound during the first three BWP. The summary is limited to these three periods as they are within the potential opening and closing dates of the flounder fishery for 2016.

5.3.2.5.1 Biweekly Period 1 (BWP1)

Expanding the Hatteras corridor to the Brooks Point boundary line would lead to a reduction in predicted sea turtle takes and bycatch per unit effort of around 70% in all effort redistribution scenarios (Appendix B, tables 26 and 27, figure 39). This expansion would also reduce the amount of flounder catch for all effort redistribution scenarios except for scenario 4, where effort is redistributed proportionally to flounder CPUE (Appendix B, tables 28 and 29). In this effort redistribution scenario, the percent increase in flounder catch is likely to be much less than is shown in these tables, because this method of redistribution does not account for the declining rate of flounder catch as more fishermen fish in the same area and the number of available flounder declines.

5.3.2.5.2 Biweekly Period 2 (BWP2)

In this period the number of turtles caught between 2003 and 2014 is higher than in BWP1 (Appendix B, compare table 26 to 30, and figure 39 to 40). The Hatteras expansion to Brooks Point still leads to the greatest reduction of sea turtle bycatch for most the corridor expansion scenarios (Appendix B, tables 30 and 31). The expansion to Brooks Point does not lead to as pronounced a decrease in flounder catch, and leads to a predicted increase in some cases, particularly in effort redistribution scenario 4 (Appendix B, tables 32 and 33). Again, the increases shown in these tables for effort redistribution scenario 4 are likely not as extreme as they would be in reality.

5.3.2.5.3 Biweekly Period 3 (BWP3)

In this time period, expanding the Hatteras Corridor out to Brooks Point does not result in any decreases in turtle bycatch, as most of the bycatch is now occurring in SWGNRA 4 (Appendix B, figures 35 and 41, table 34). Expanding the Oregon Inlet corridor to the Great Island boundary line would lead to 35% decrease in the number of turtles caught, and less than 1% increase in flounder catch for all scenarios except effort redistribution scenario 4 (Appendix B, tables 35 and 37).

5.3.2.5.4 Biweekly Periods 4, 5, & 6

Because the fishing season for southern flounder is proposed to end in mid-October 2016 we do not discuss sea turtle and flounder catch during BWPs 4, 5, and 6. However, the tables and figures showing results from BWP 4, 5, and 6 can be found in Appendix B, between pages 218 and 233.

5.3.3 SUMMARY

- Sea turtle BPUE is the highest during the first two weeks of September.
- Flounder CPUE is relatively constant throughout September and October.
- According to the new southern flounder supplement strategy, the fishery will close on October 16th, 2016. Due to this shortened fishing season, higher levels of effort may occur in September as compared to previous years. Those elevated effort levels could coincide with the period of highest sea turtle BPUE, leading to increased sea turtle bycatch rates.
- If the fishery opens in early September, expanding the Hatteras corridor to the Brooks Point boundary line during this month could help minimize sea turtle bycatch.
- Alternatively (or in conjunction with the corridor expansion), opening the southern flounder season after the first two weeks of September have passed could help mitigate the impact of elevated effort levels on sea turtle bycatch rates.

6. References

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7. Appendix A: Atlantic Sturgeon Bycatch and Distribution Supporting Figures

CATCH PER UNIT EFFORT/CUMULATIVE STUGEON DAYS - SEASONAL

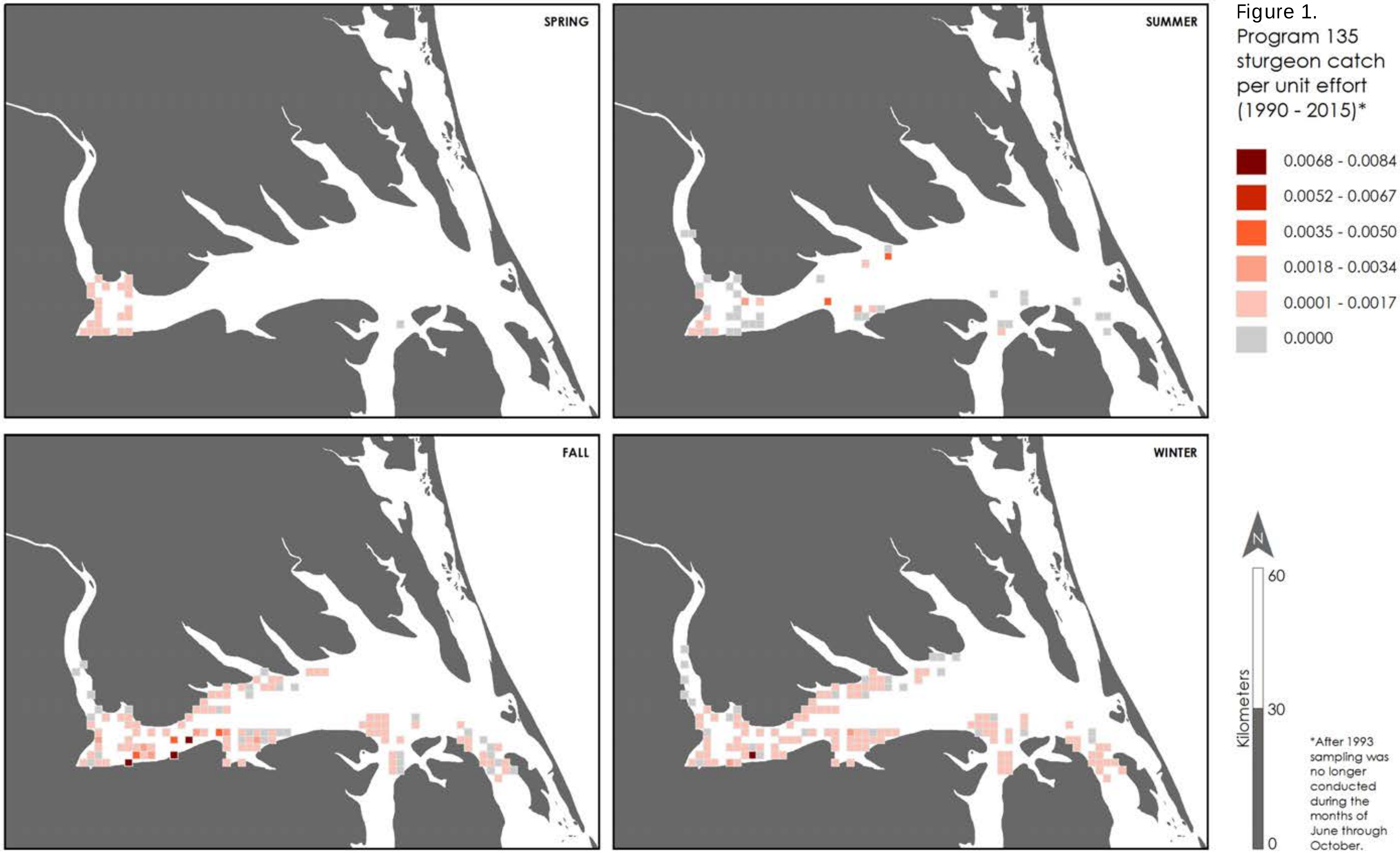


Figure 1. Program 135 sturgeon catch per unit effort (1990 - 2015)*

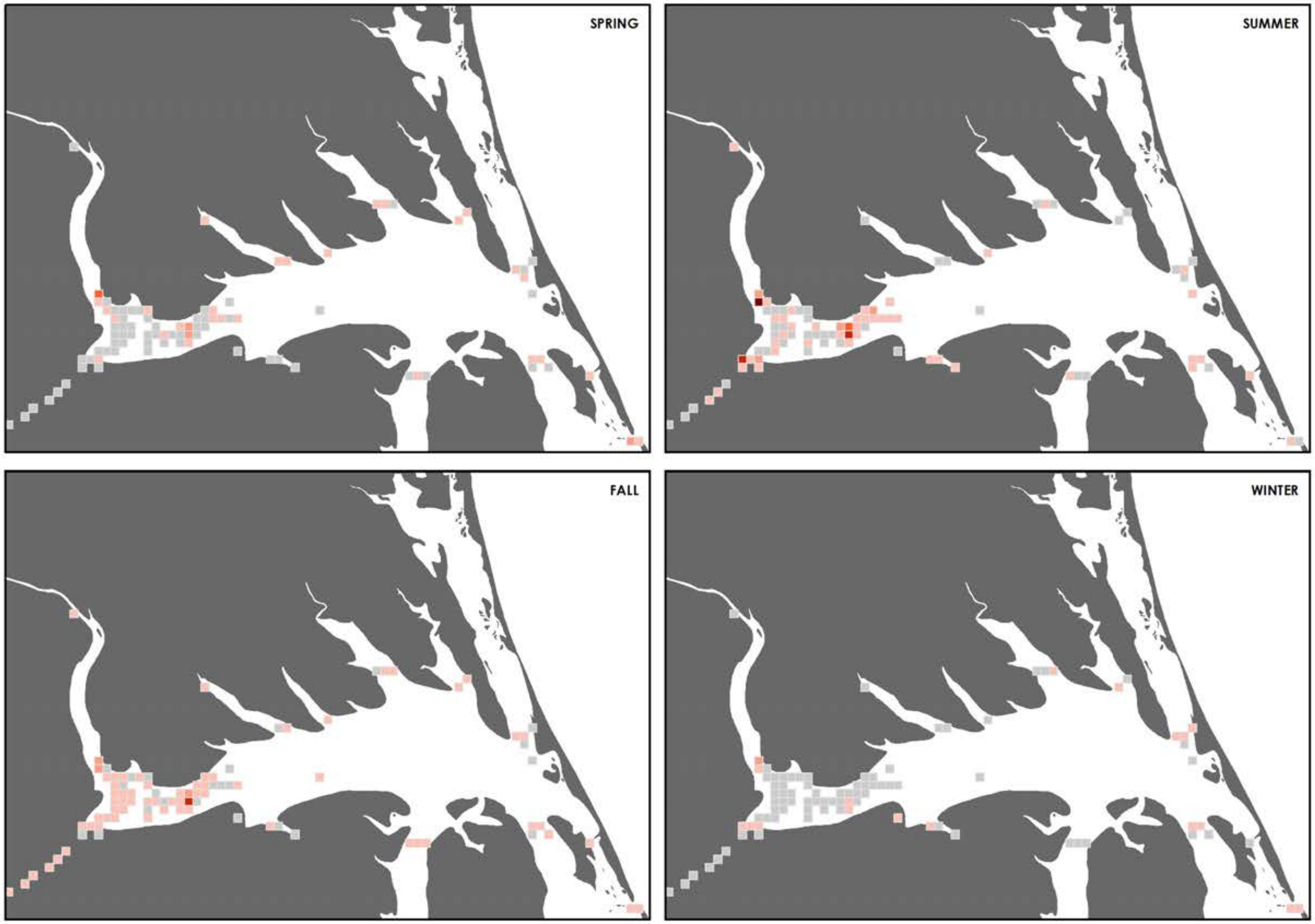


Figure 2.
Program 356 cumulative sturgeon days (2011 - 2015)

INDIVIDUAL DATASET MAPS
CATCH PER UNIT EFFORT/CUMULATIVE STURGEON DAYS - SEASONAL

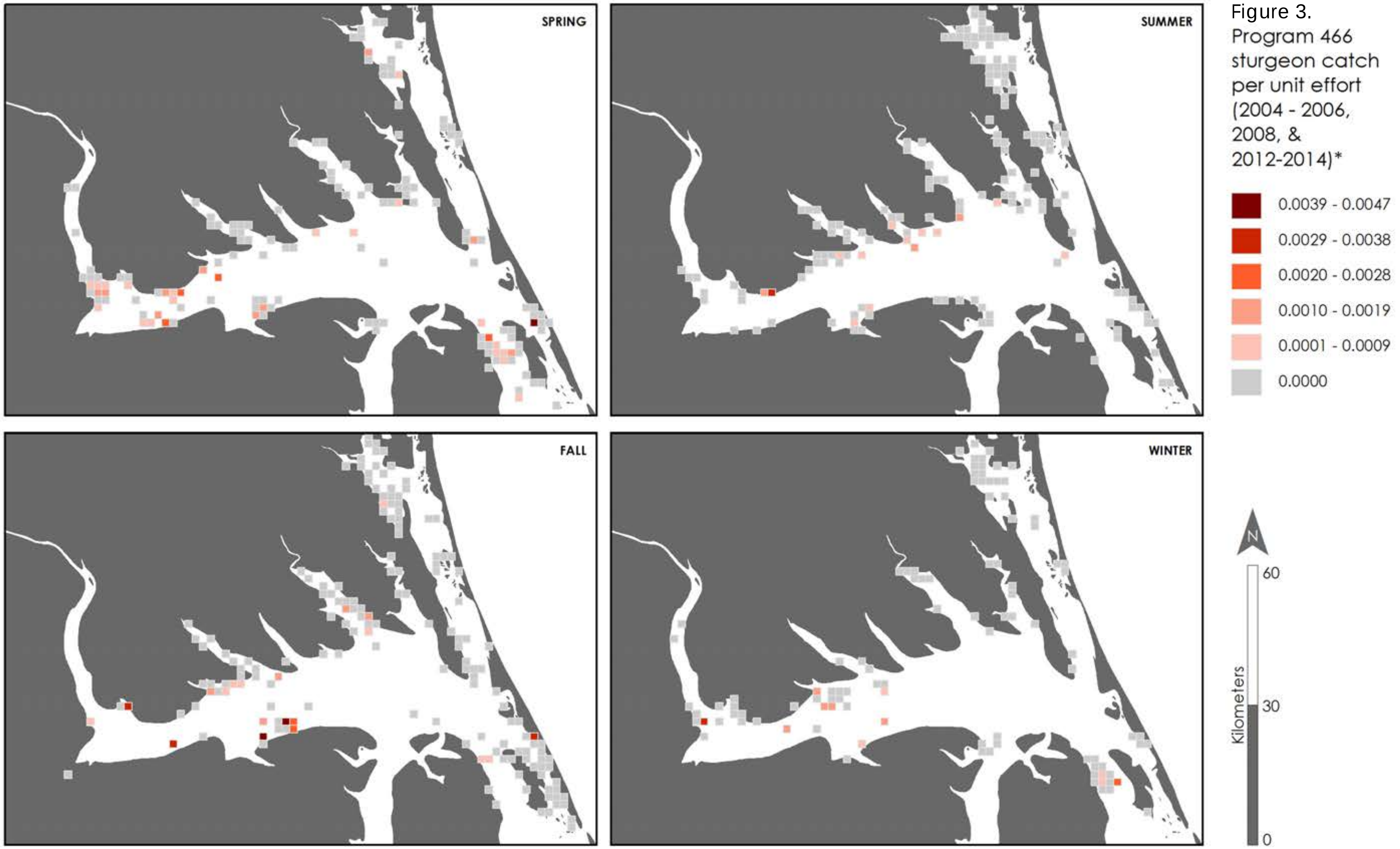


Figure 3. Program 466 sturgeon catch per unit effort (2004 - 2006, 2008, & 2012-2014)*

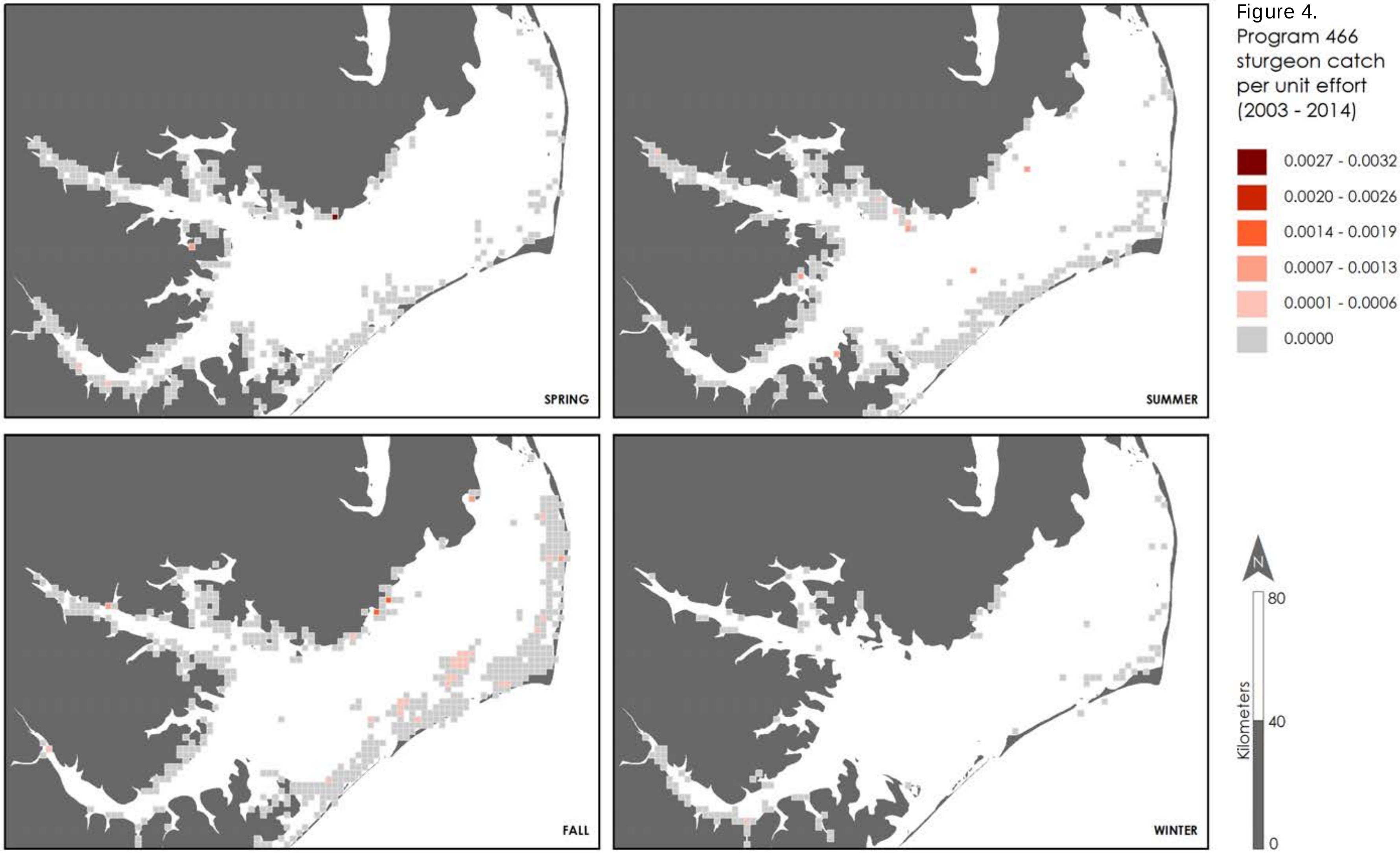


Figure 4.
Program 466
sturgeon catch
per unit effort
(2003 - 2014)

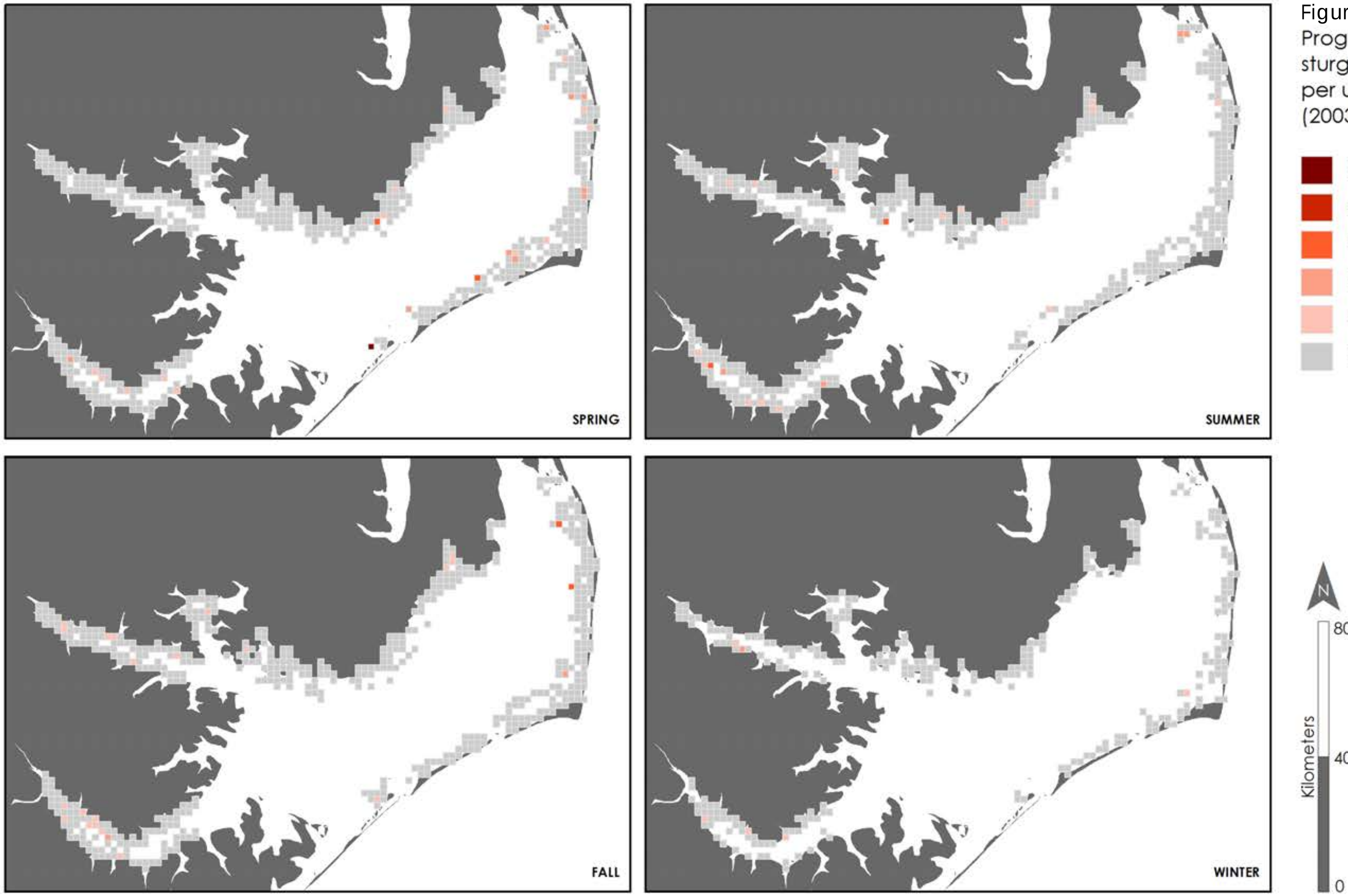


Figure 5.
Program 915 sturgeon catch per unit effort (2003 - 2014)

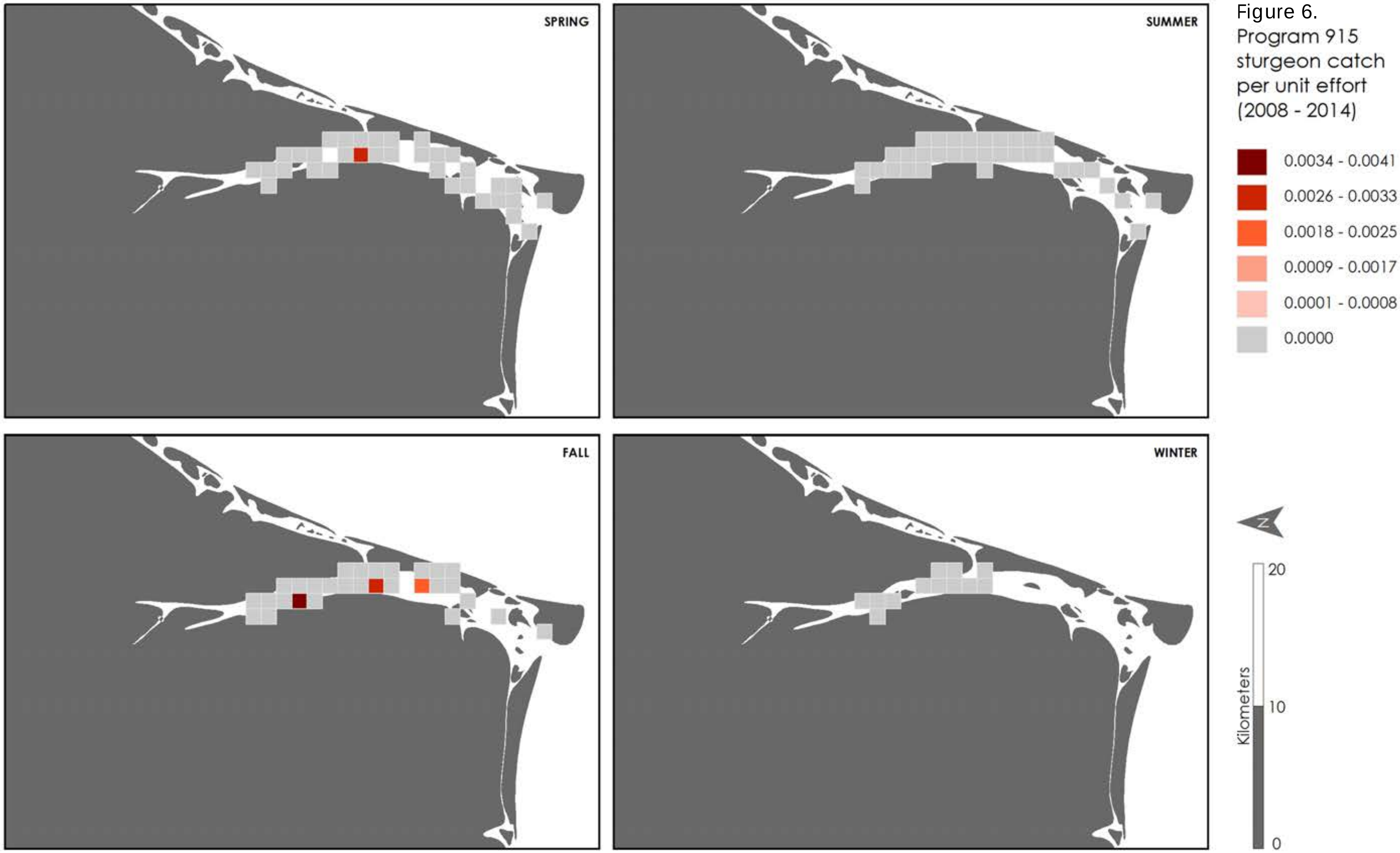


Figure 6.
Program 915 sturgeon catch per unit effort (2008 - 2014)

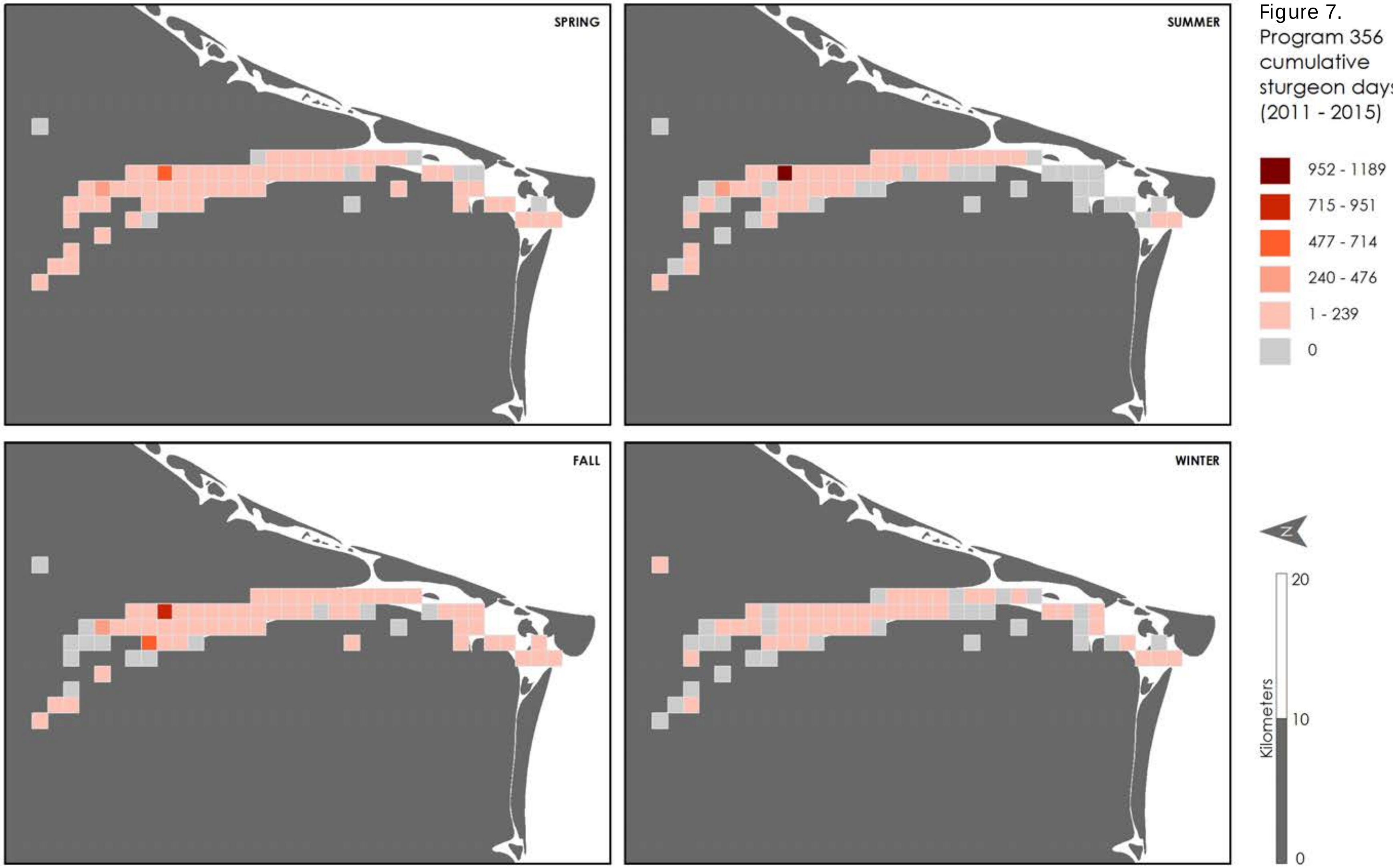


Figure 7. Program 356 cumulative sturgeon days (2011 - 2015)

NUMBER OF STURGEON/CUMULATIVE STURGEON DAYS - SEASONAL

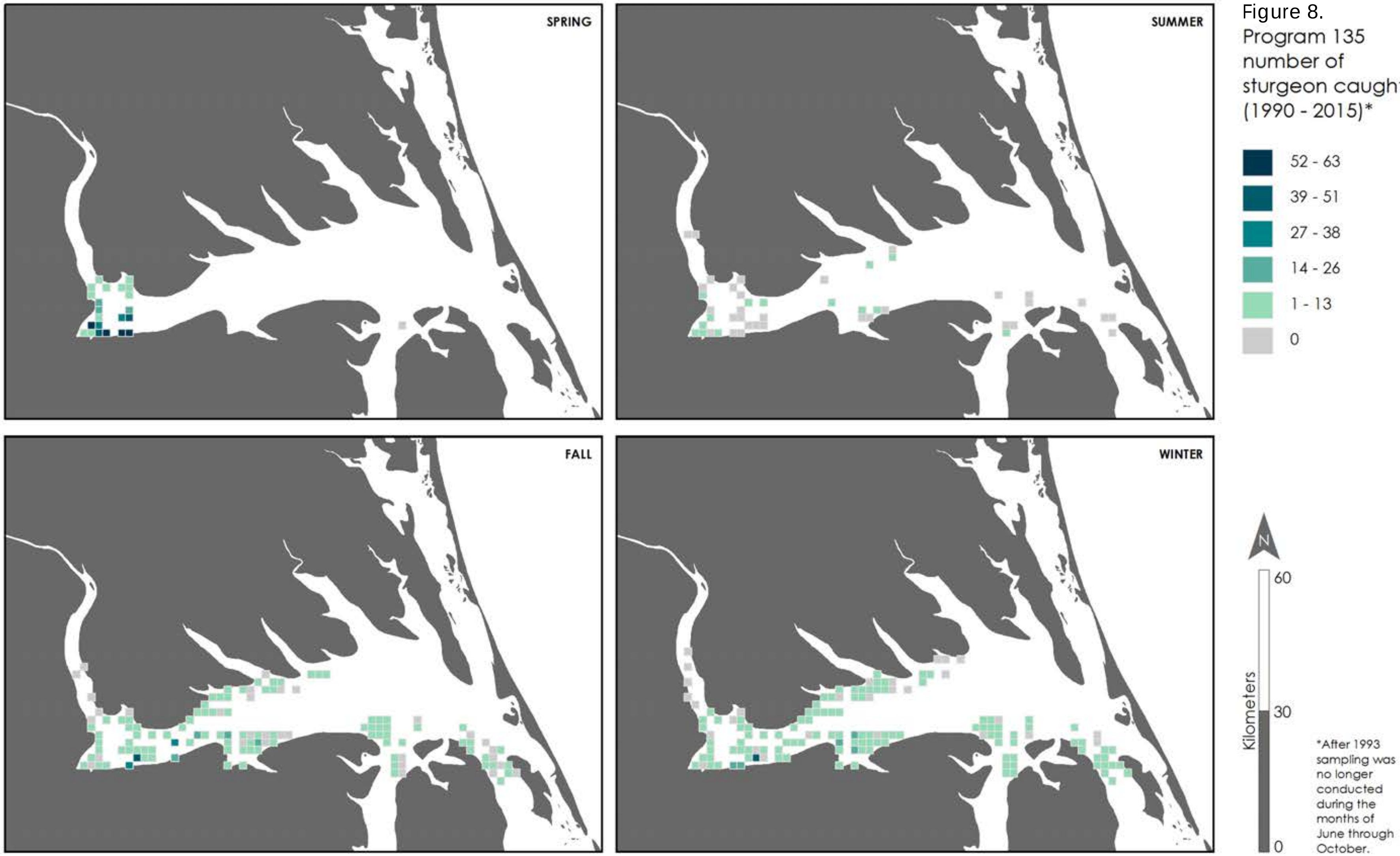


Figure 8. Program 135 number of sturgeon caught (1990 - 2015)*

*After 1993 sampling was no longer conducted during the months of June through October.

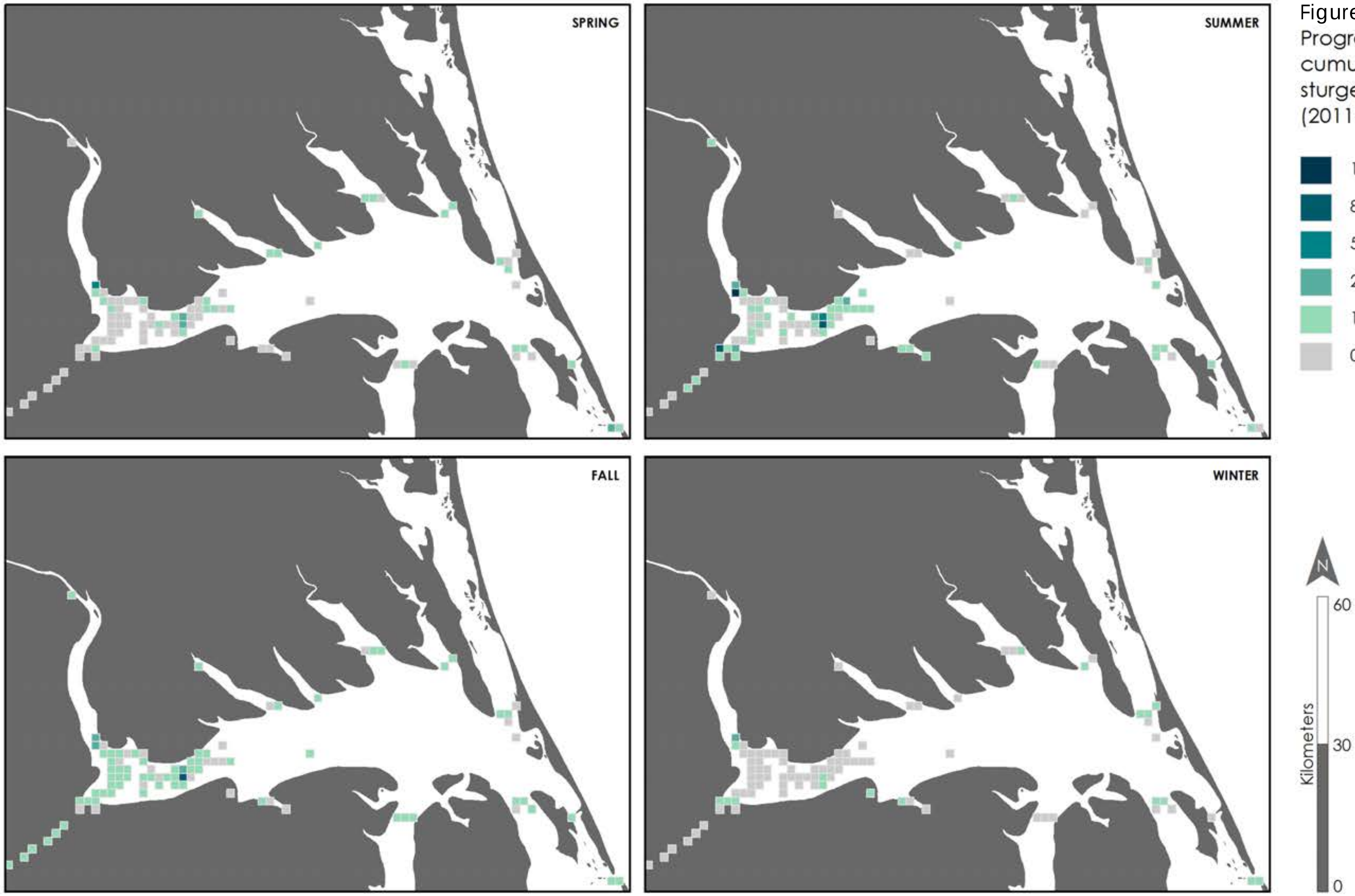


Figure 9.
Program 356 cumulative sturgeon days (2011 - 2015)

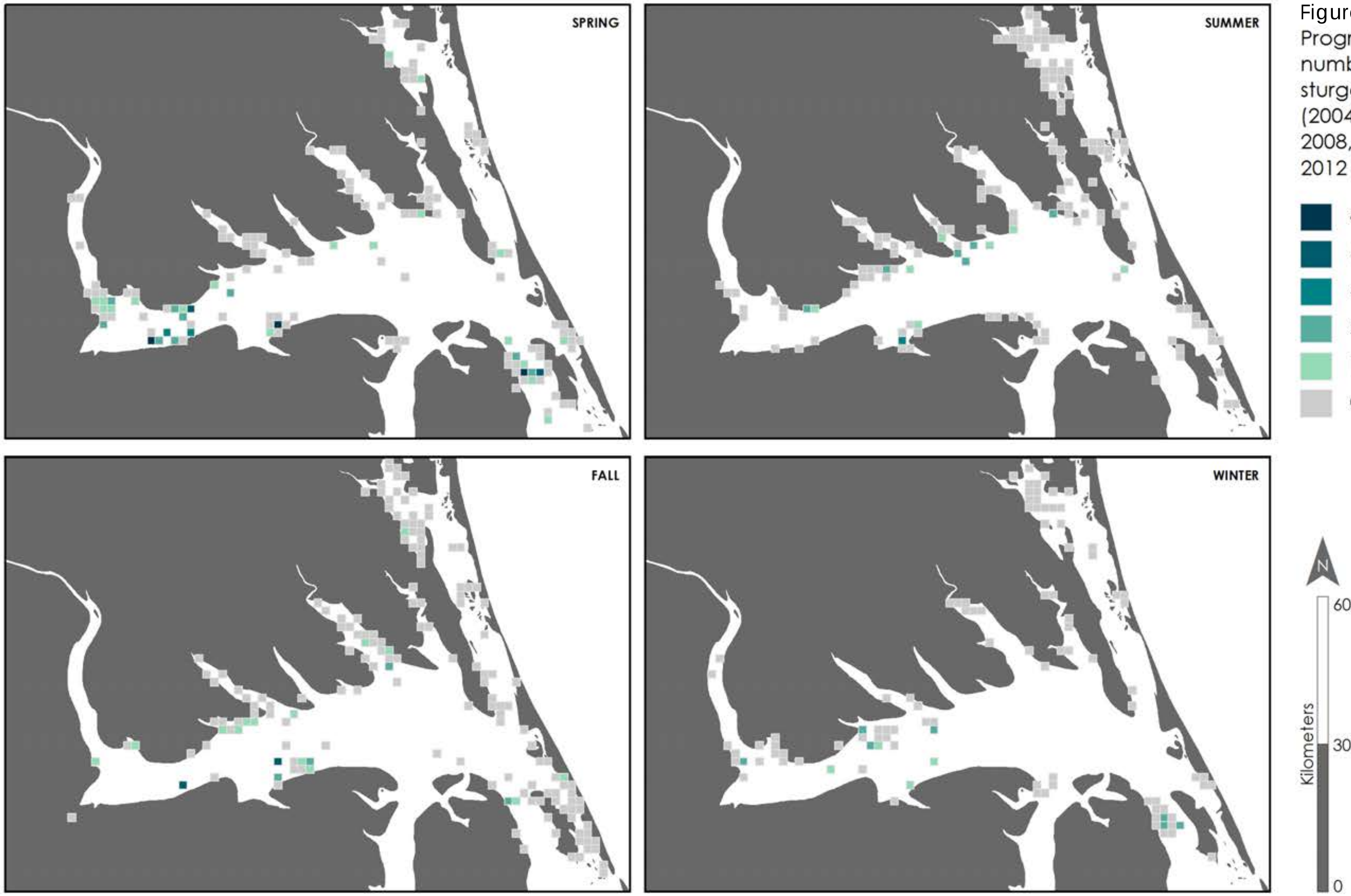


Figure 10.
Program 466 number of sturgeon caught (2004 - 2006, 2008, & 2012 - 2014)

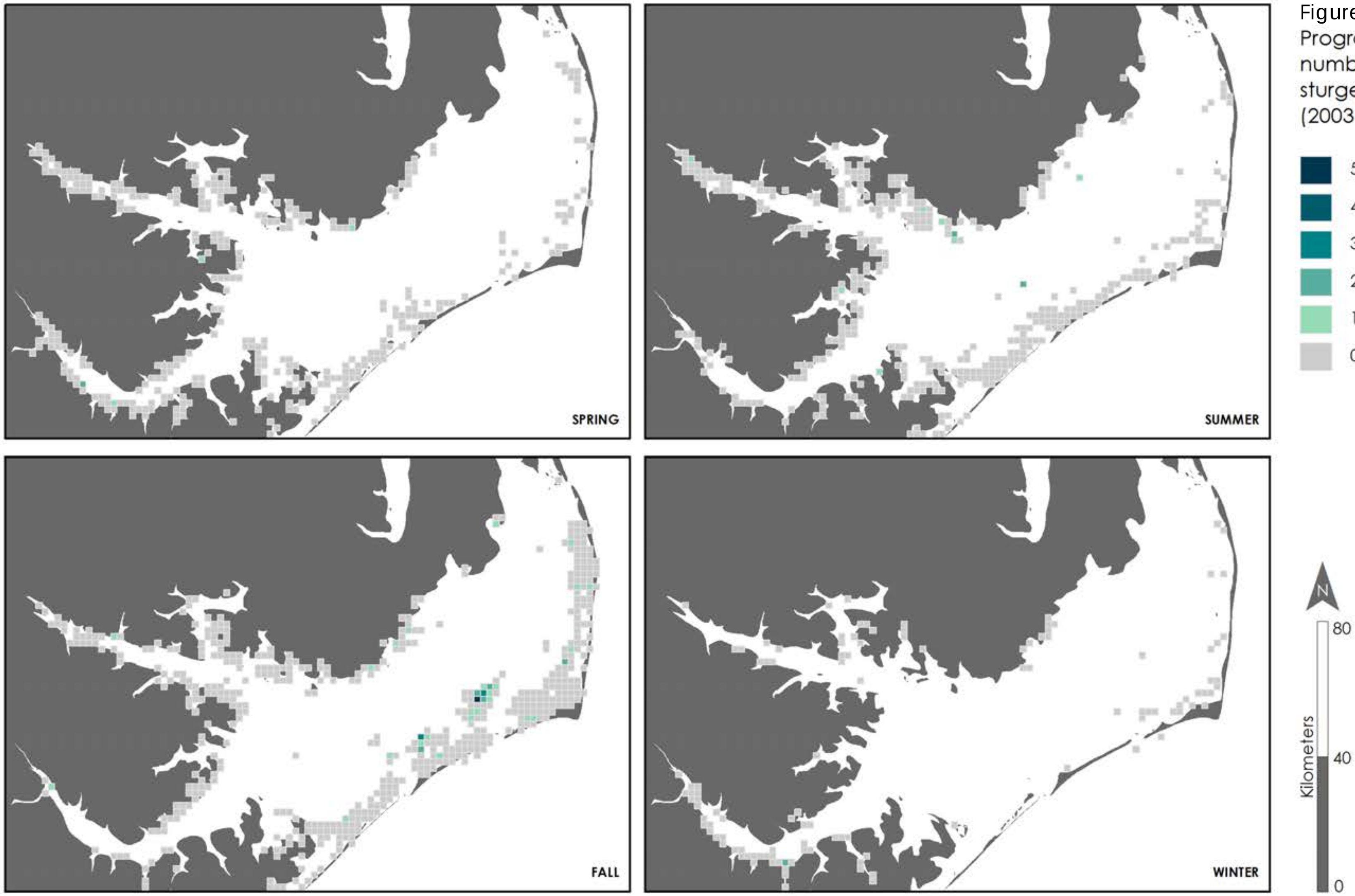


Figure 11.
Program 466
number of
sturgeon caught
(2003 - 2014)

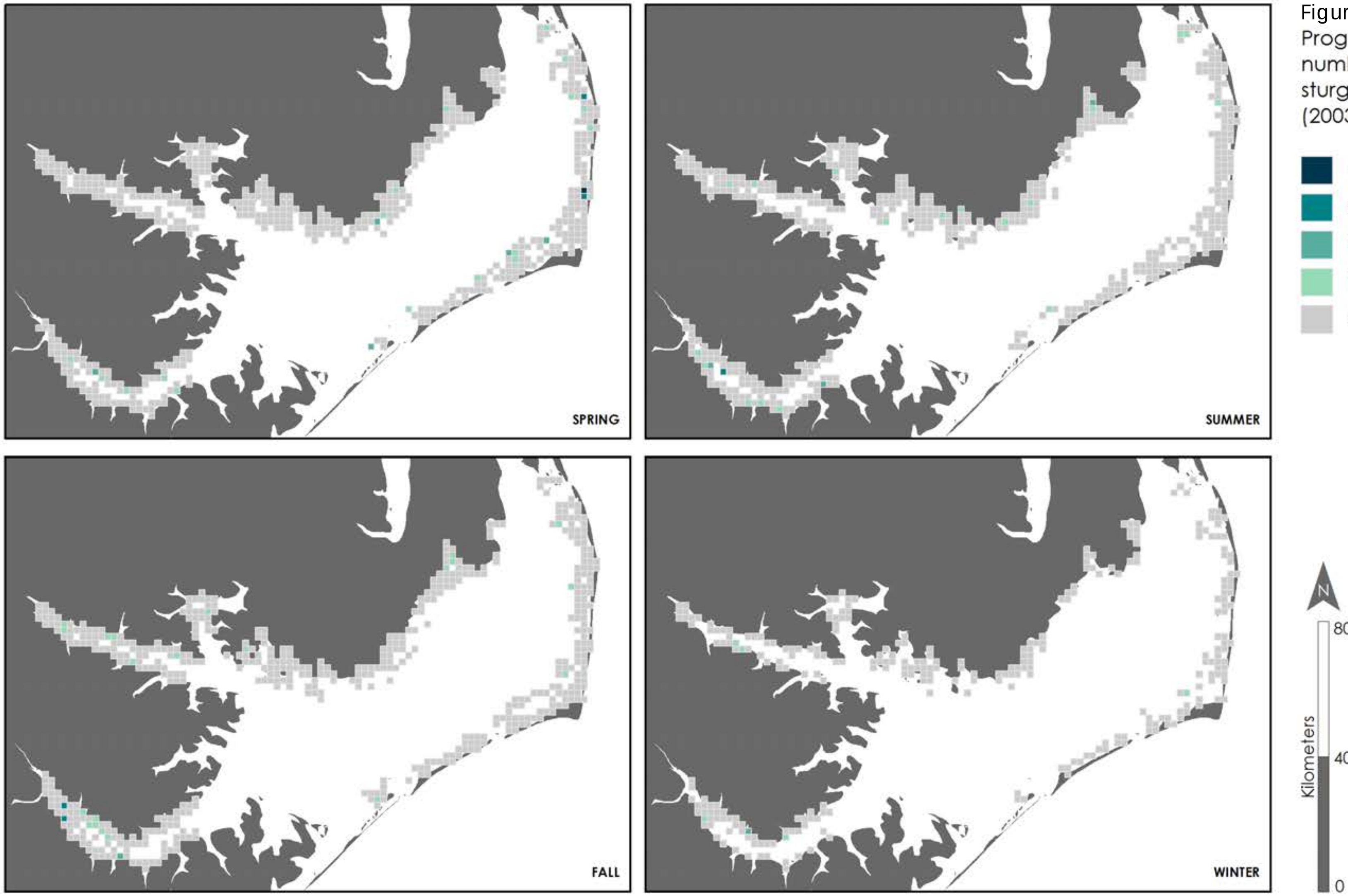


Figure 12.
Program 915
number of
sturgeon caught
(2003 - 2014)

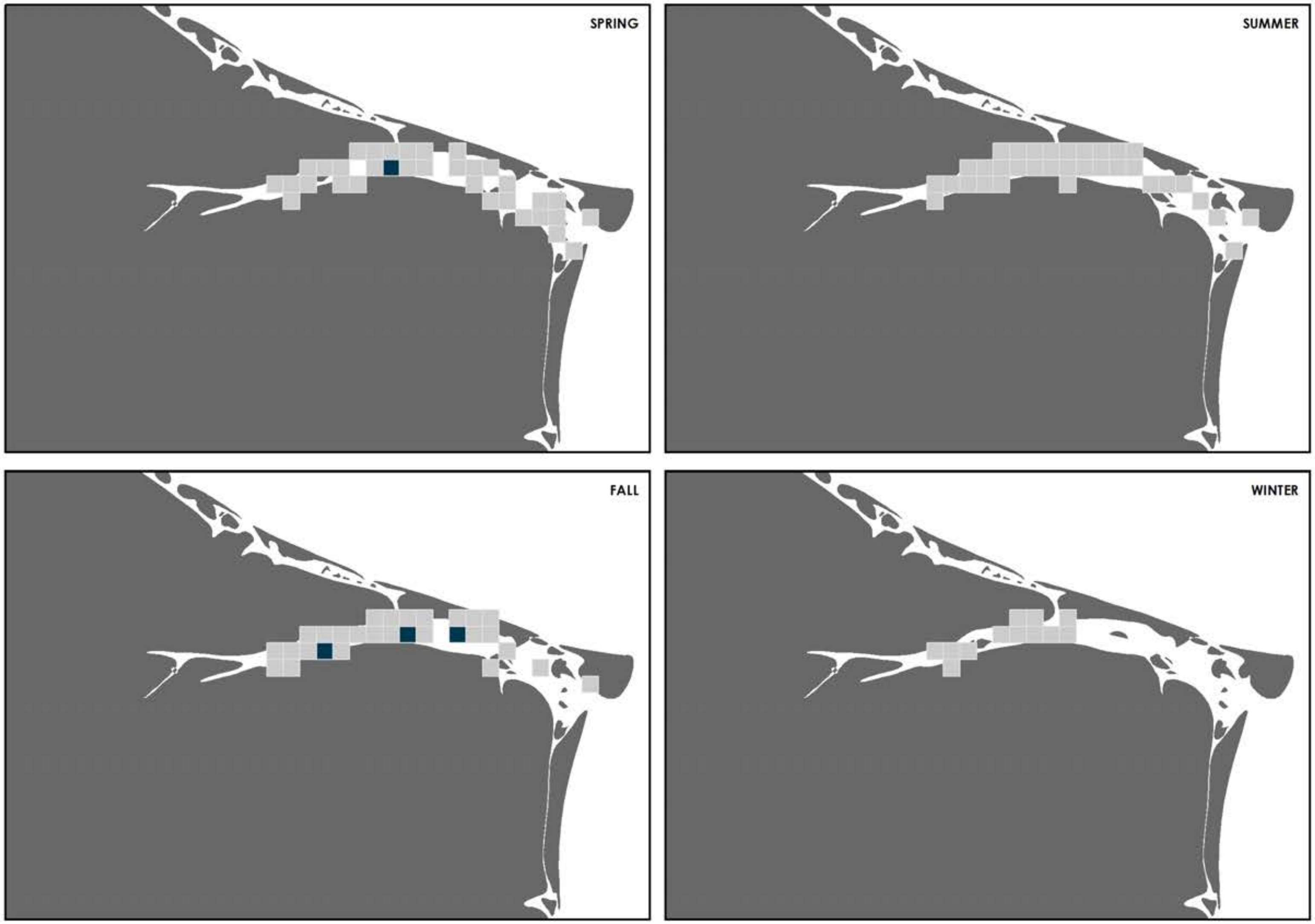


Figure 13.
Program 915
number of
sturgeon caught
(2008 - 2014)

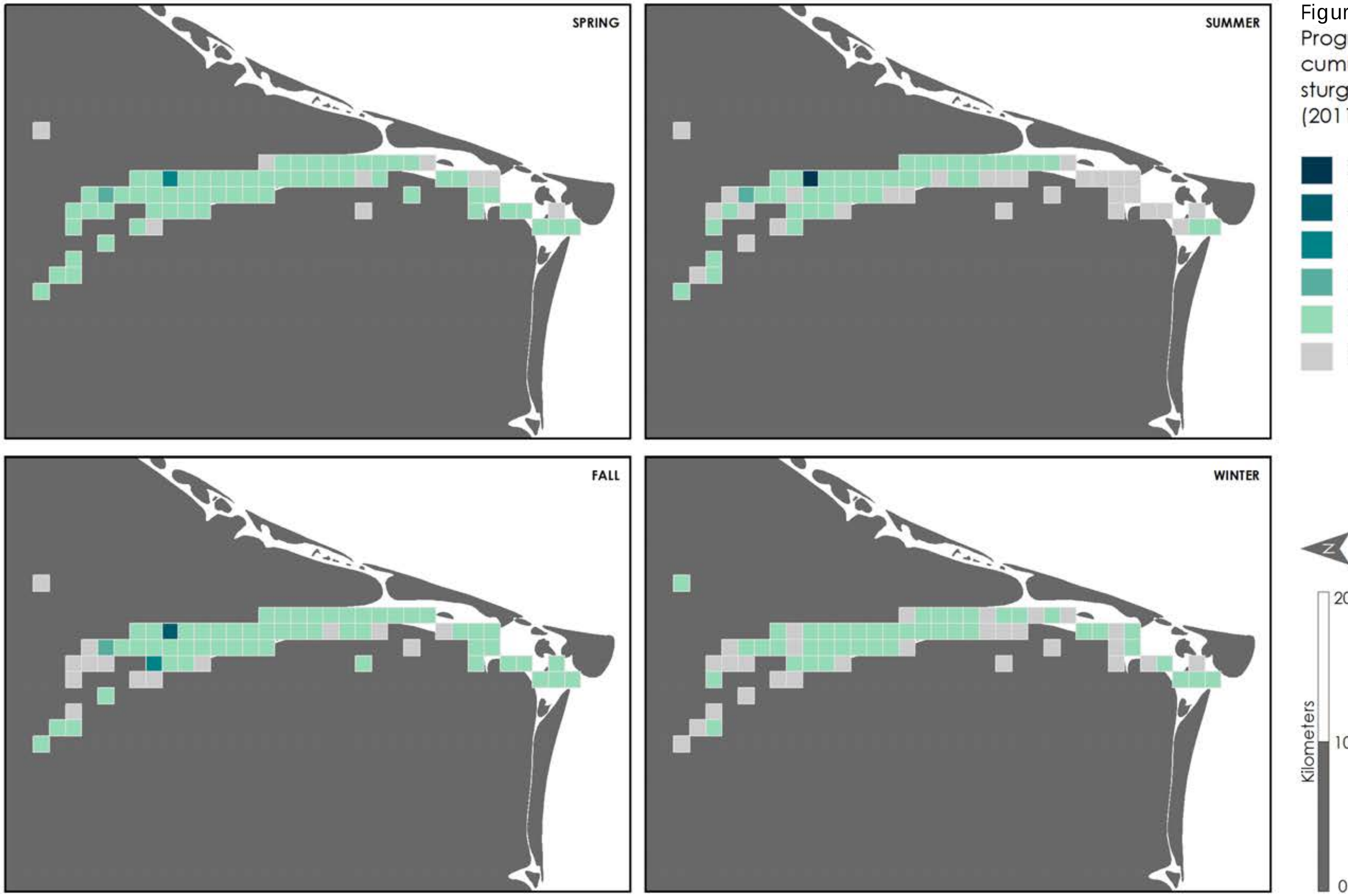


Figure 14. Program 356 cumulative sturgeon days (2011 - 2015)

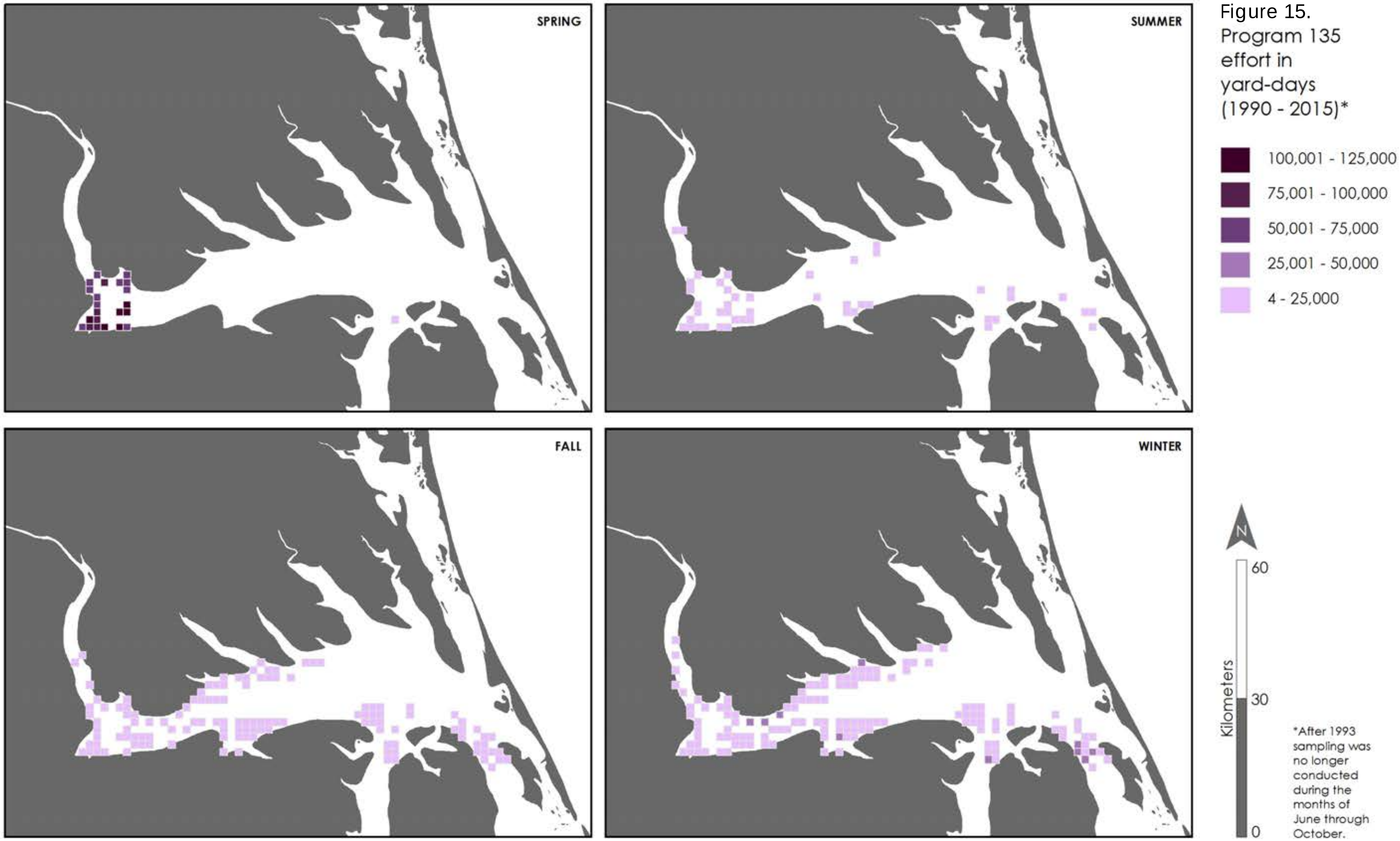


Figure 15. Program 135 effort in yard-days (1990 - 2015)*

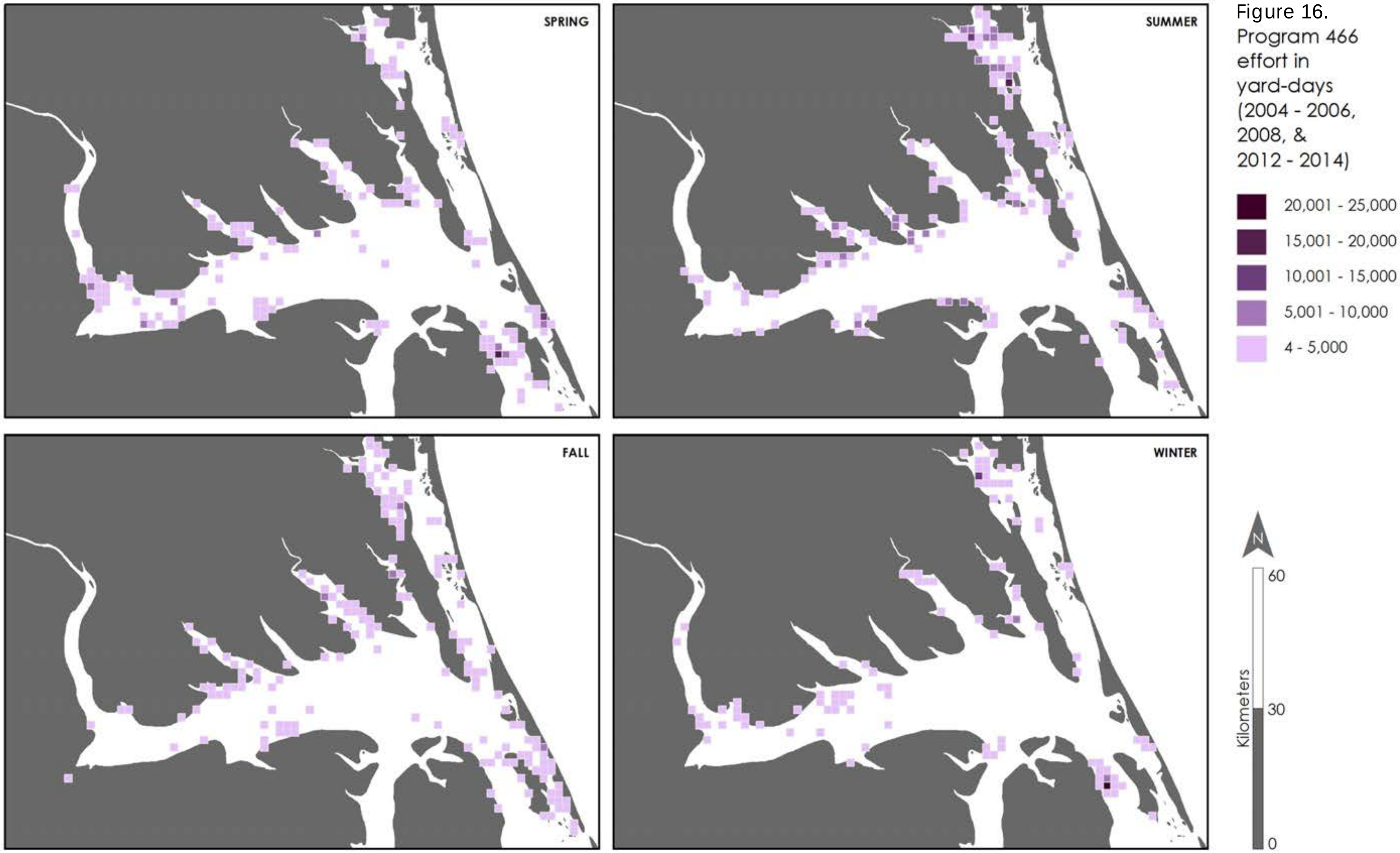


Figure 16. Program 466 effort in yard-days (2004 - 2006, 2008, & 2012 - 2014)

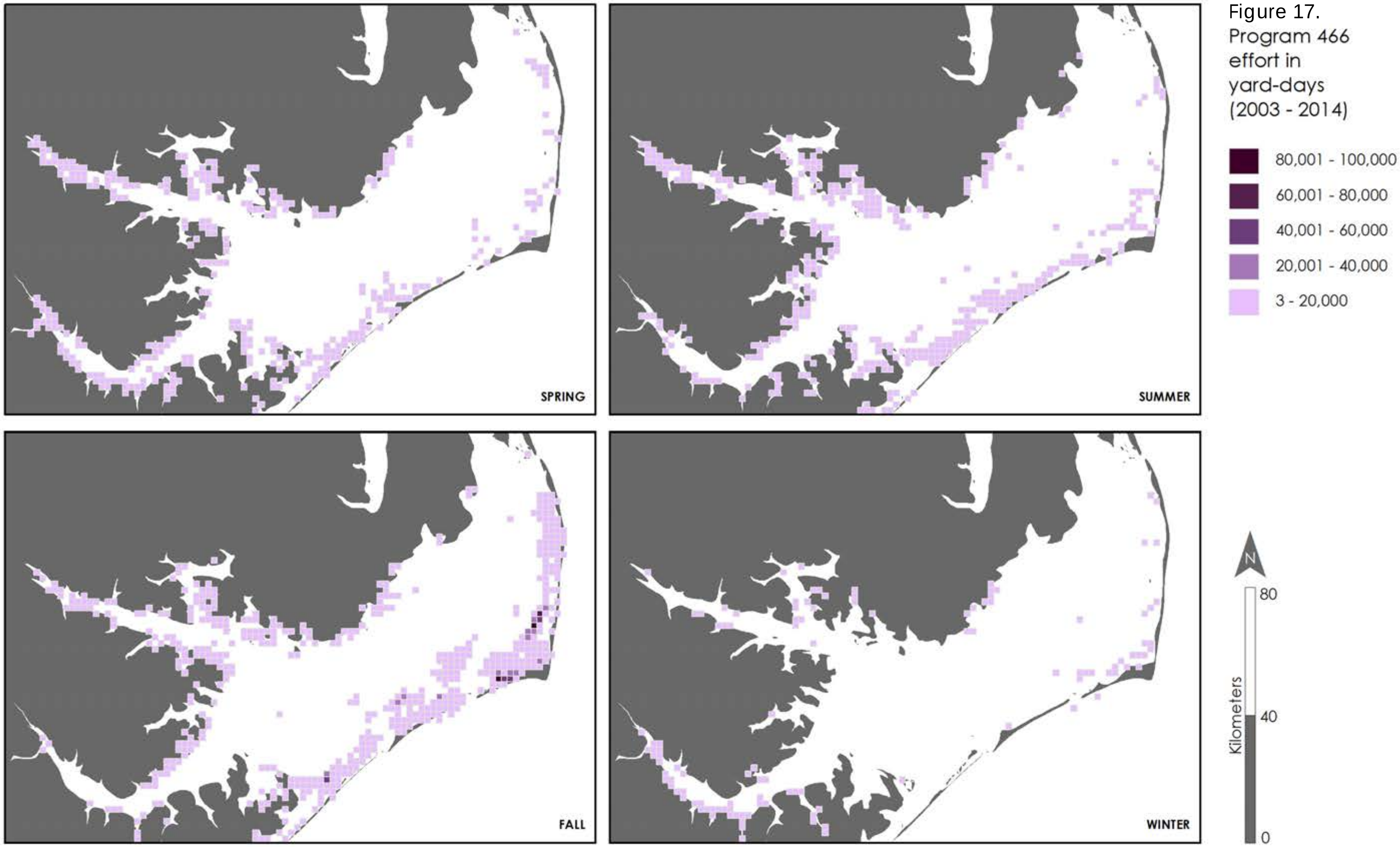


Figure 17.
Program 466
effort in
yard-days
(2003 - 2014)

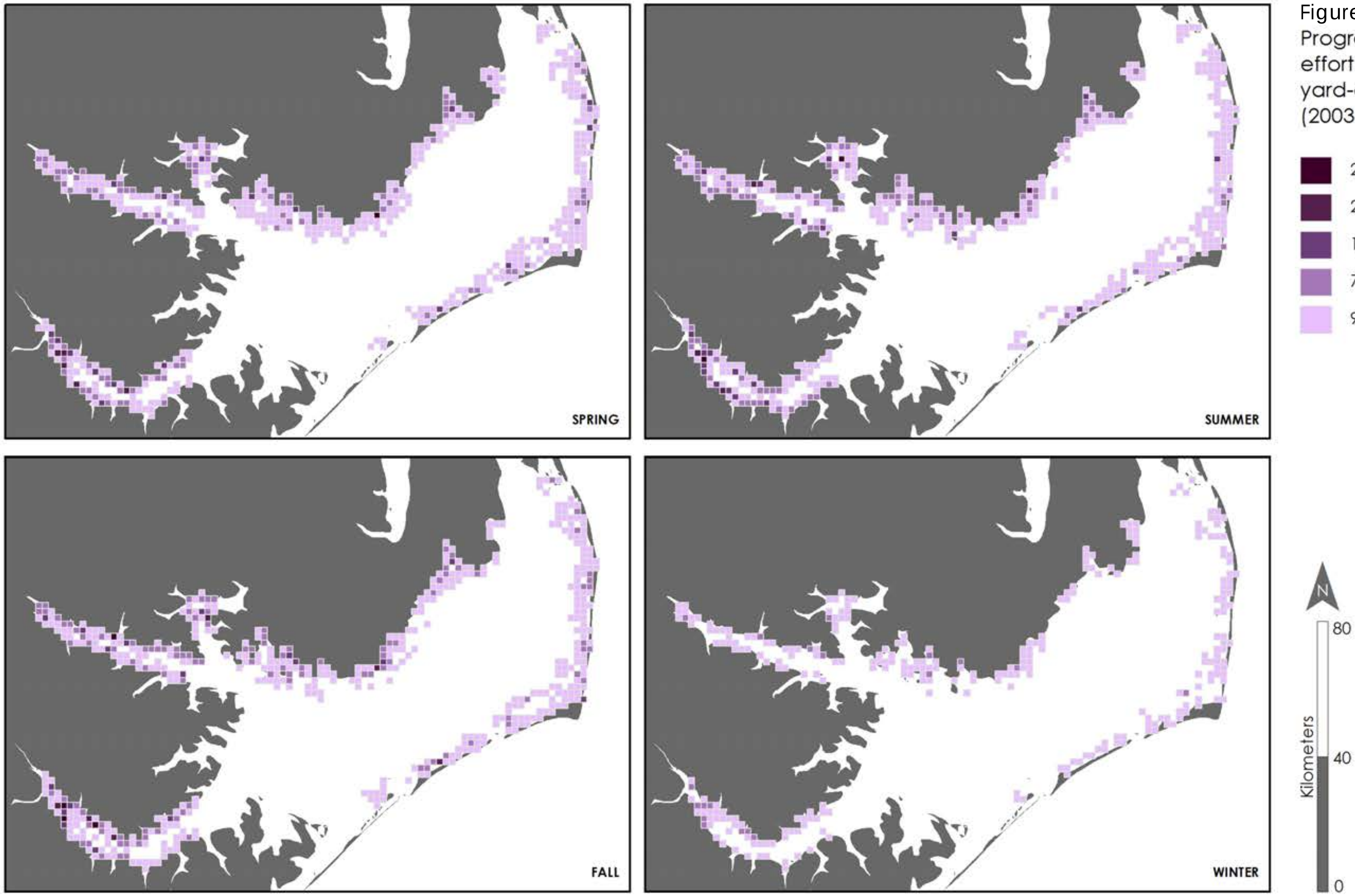


Figure 18. Program 915 effort in yard-days (2003 - 2014)

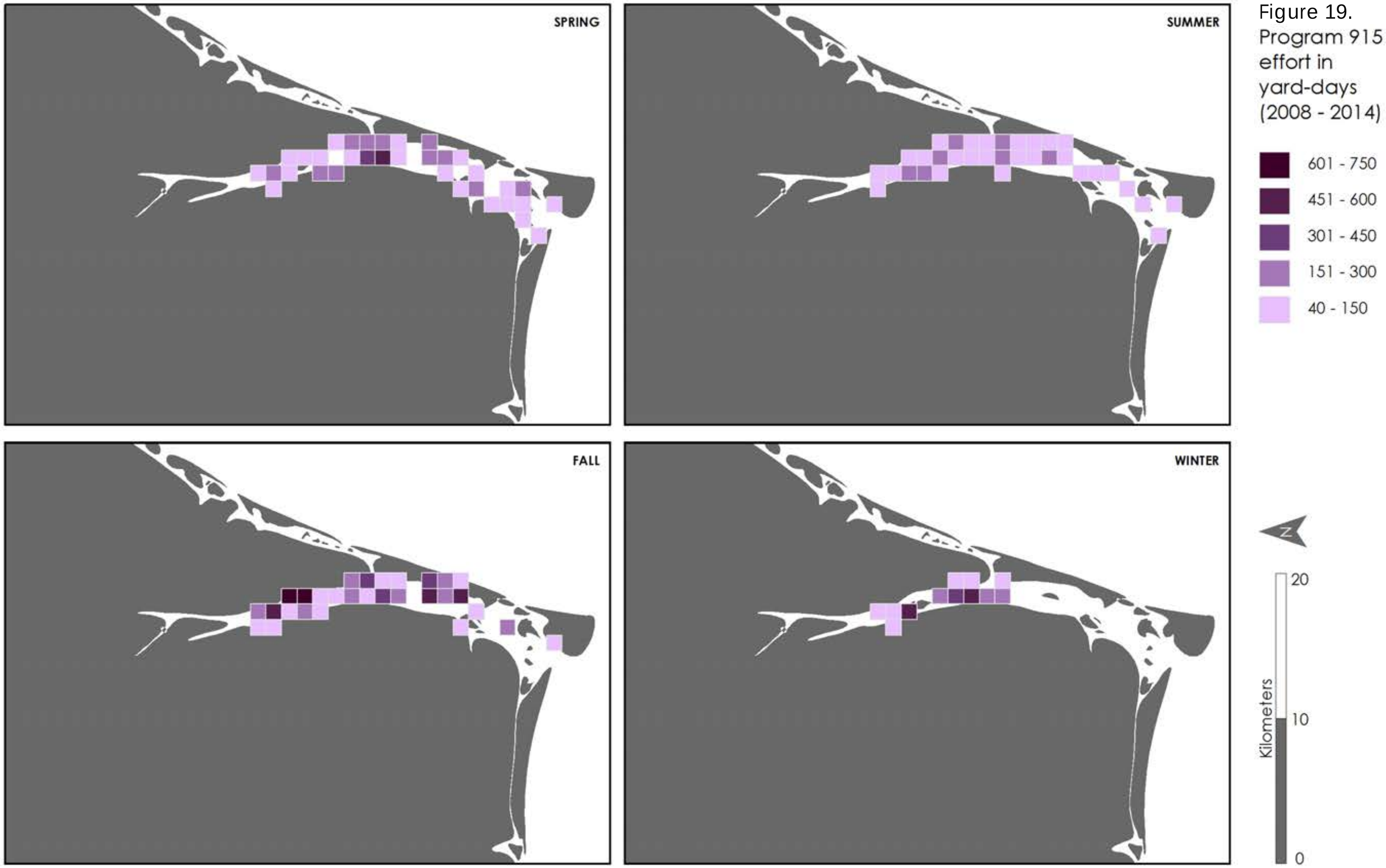


Figure 19. Program 915 effort in yard-days (2008 - 2014)

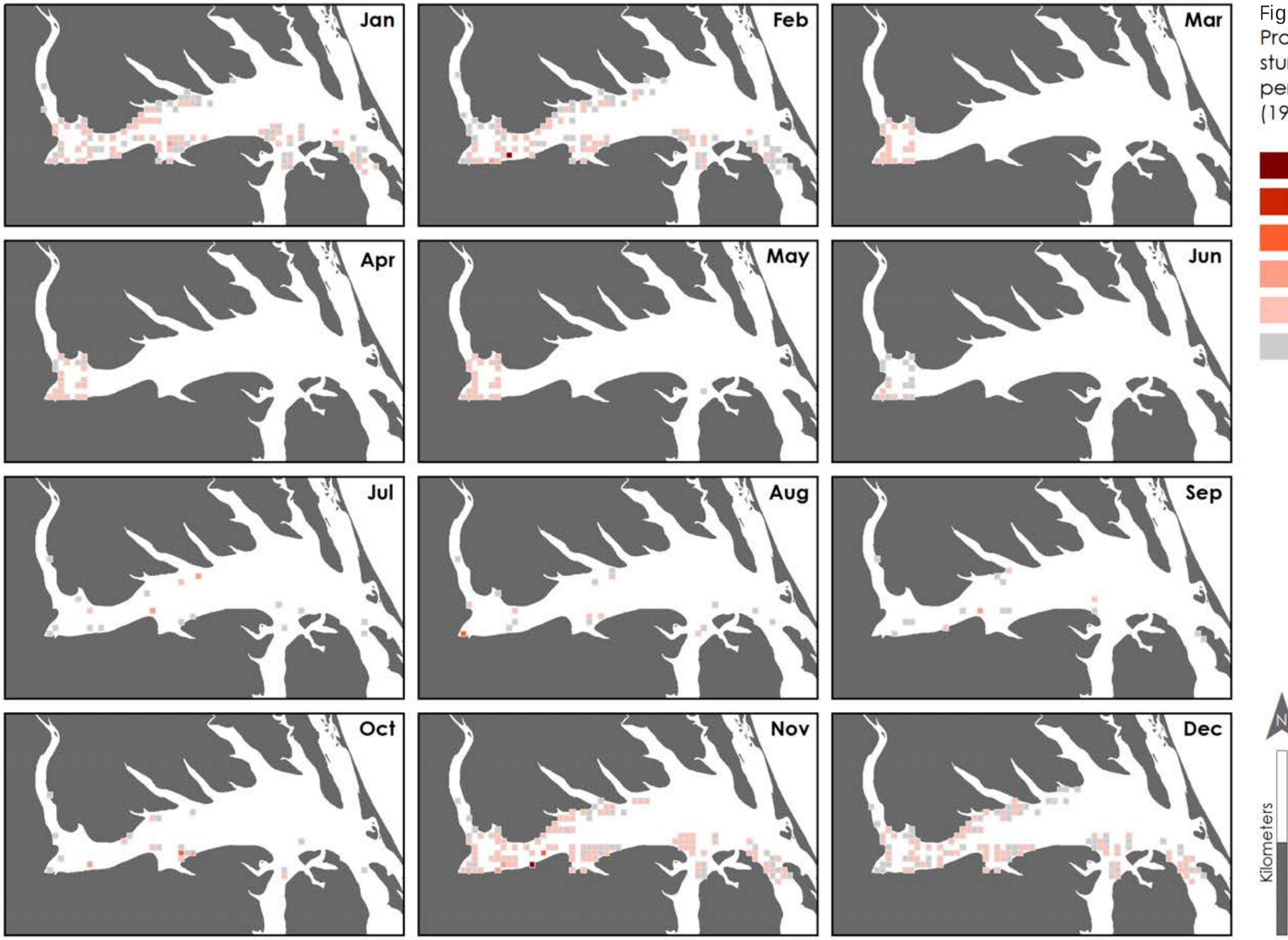


Figure 20. Program 135 sturgeon catch per unit effort (1990 - 2015)*

*After 1993 sampling was no longer conducted during the months of June through October.

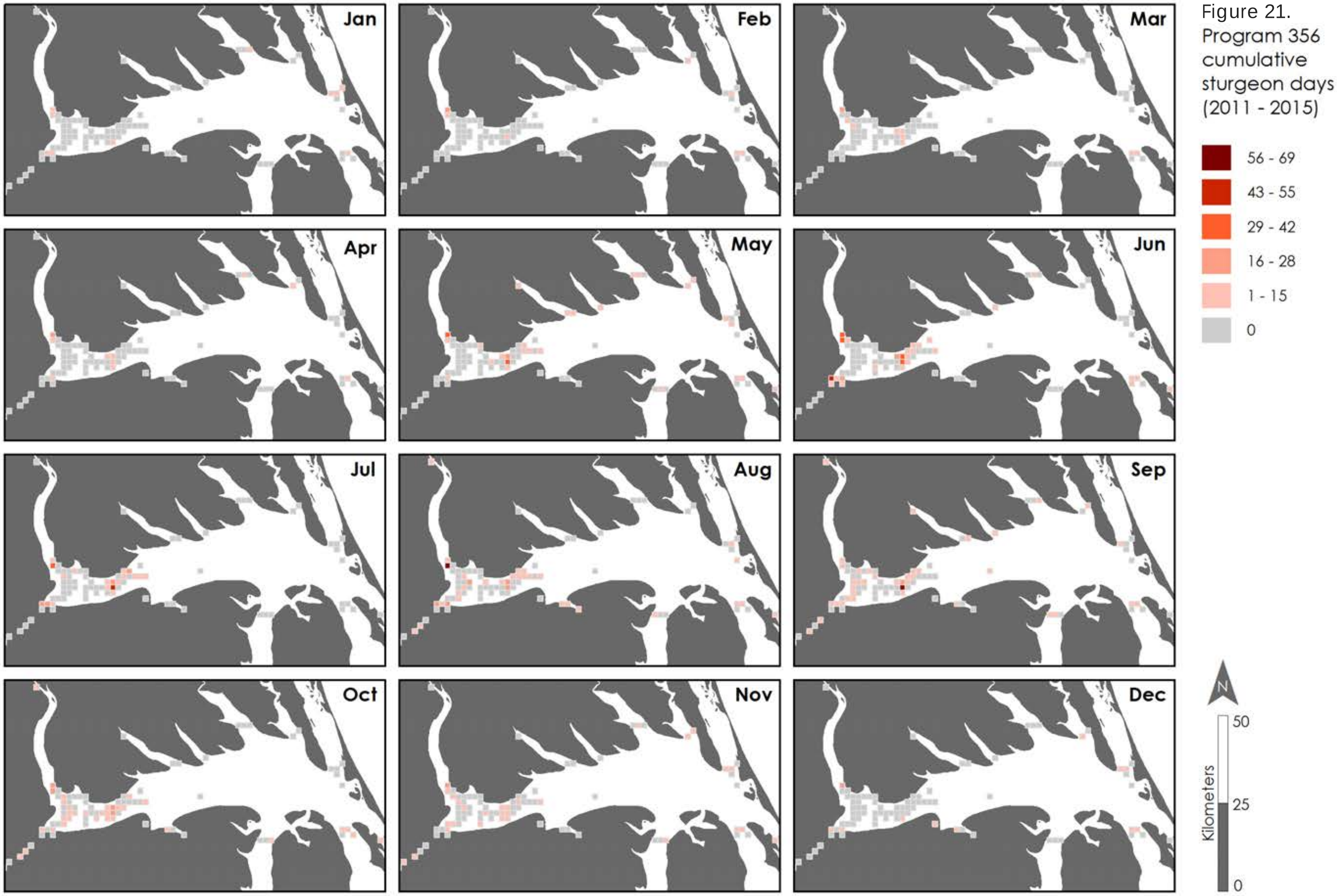


Figure 21.
Program 356
cumulative
sturgeon days
(2011 - 2015)

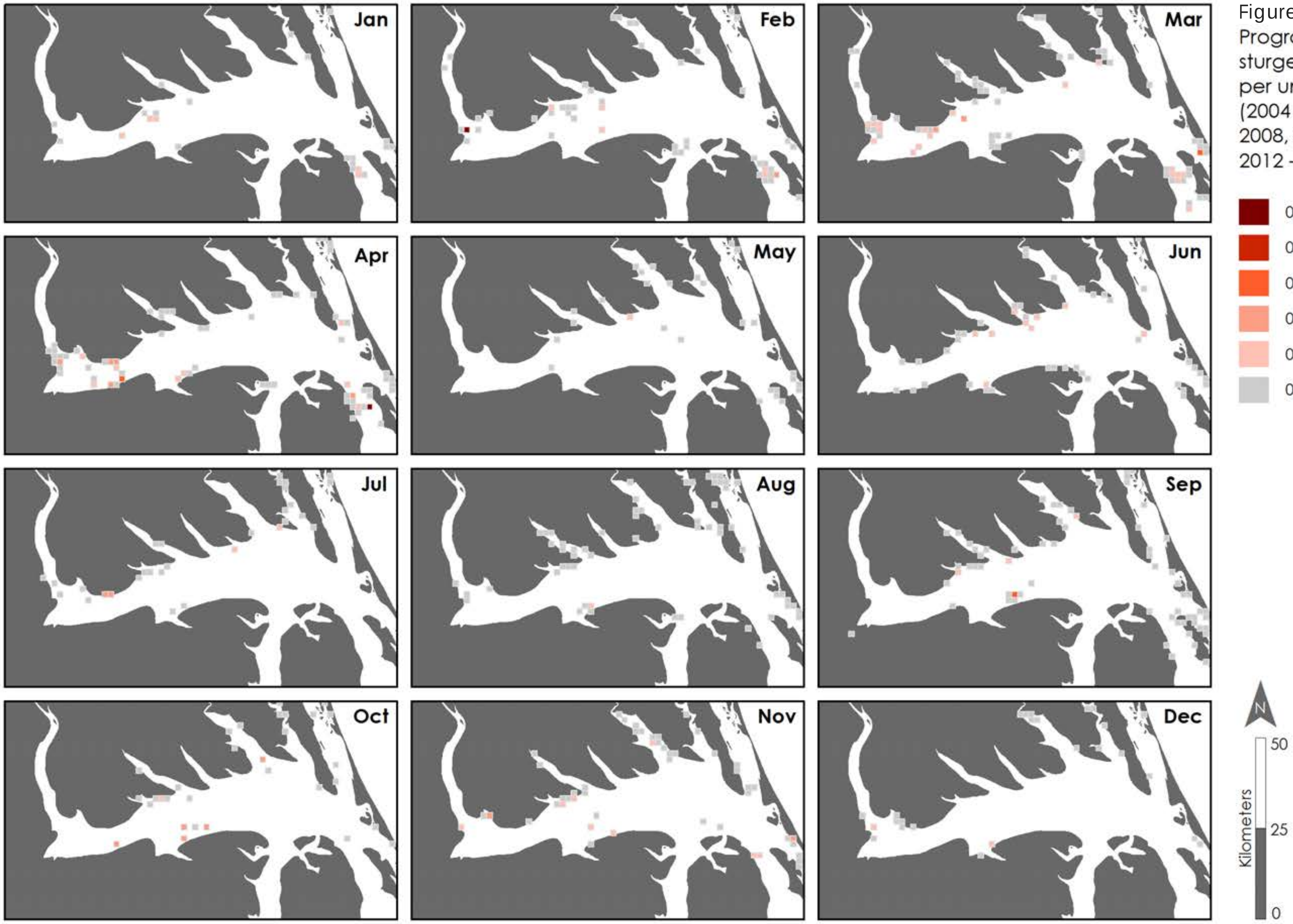


Figure 22.
Program 466 sturgeon catch per unit effort (2004 - 2006, 2008, & 2012 - 2014)

Figure 23.
Program 466 sturgeon catch per unit effort (2003 - 2014)

INDIVIDUAL DATASET MAPS

CATCH PER UNIT EFFORT /CUMULATIVE STURGEON DAYS- MONTHLY

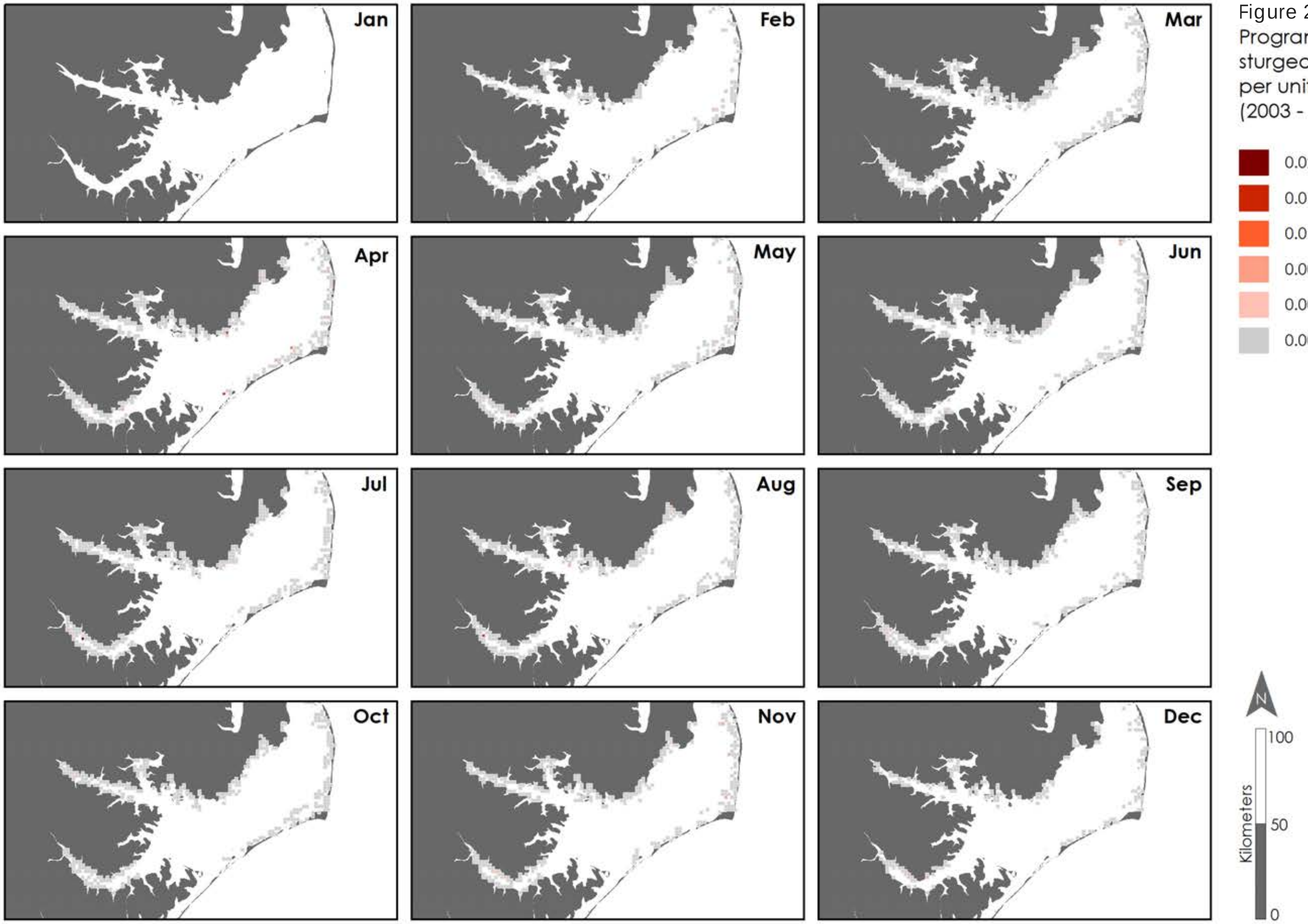


Figure 24.
Program 915 sturgeon catch per unit effort (2003 - 2014)

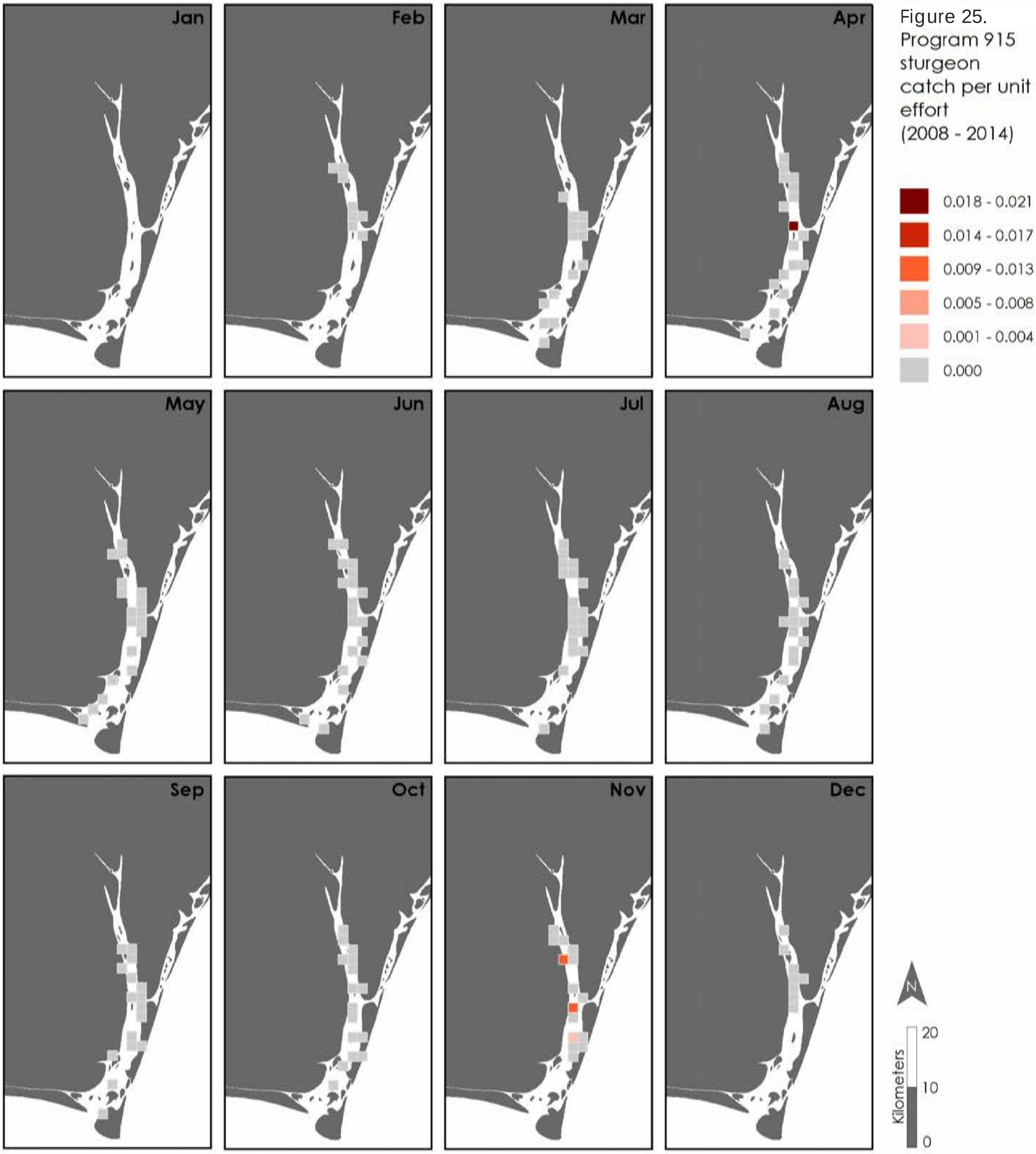


Figure 25. Program 915 sturgeon catch per unit effort (2008 - 2014)

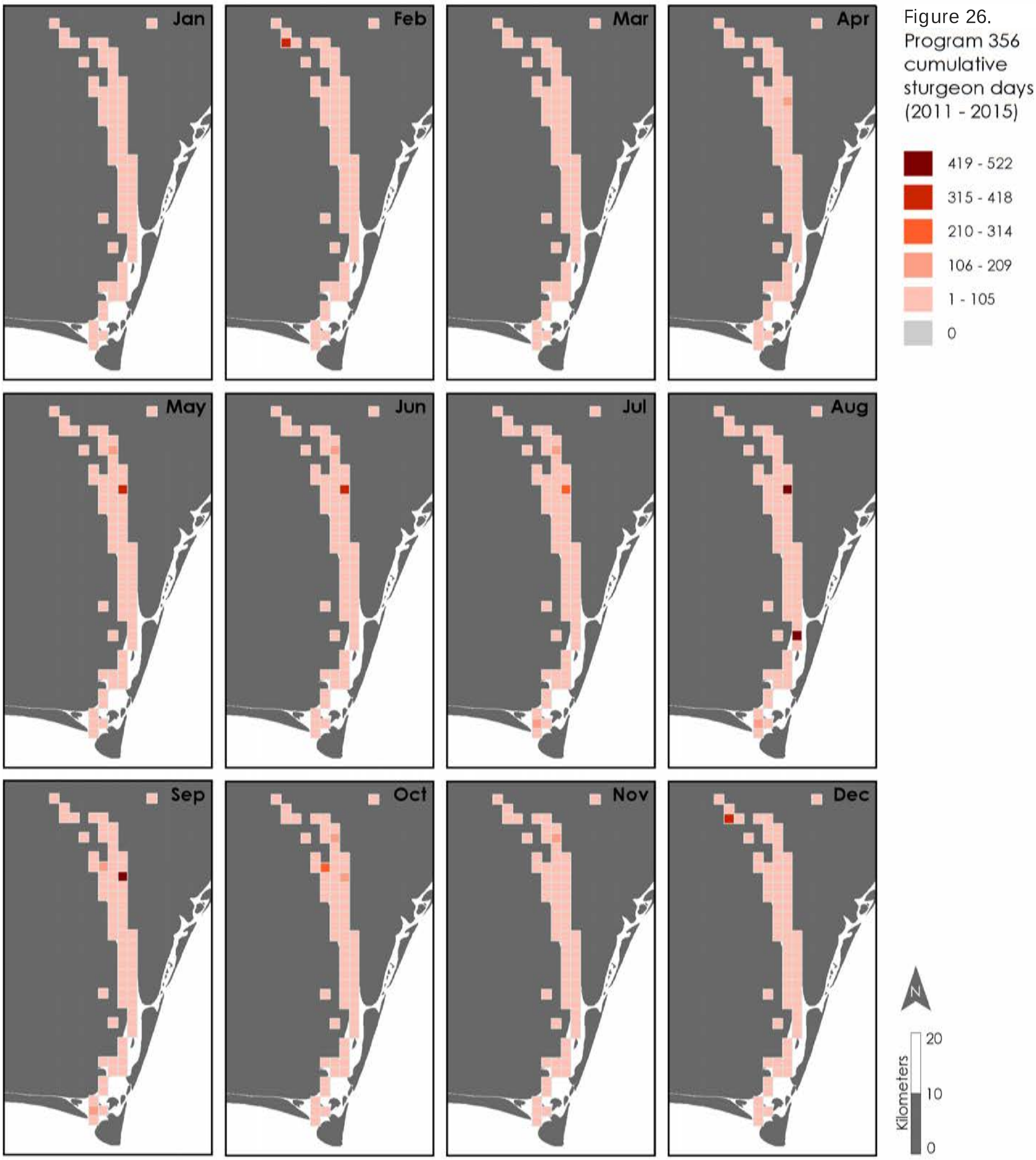


Figure 26. Program 356 cumulative sturgeon days (2011 - 2015)

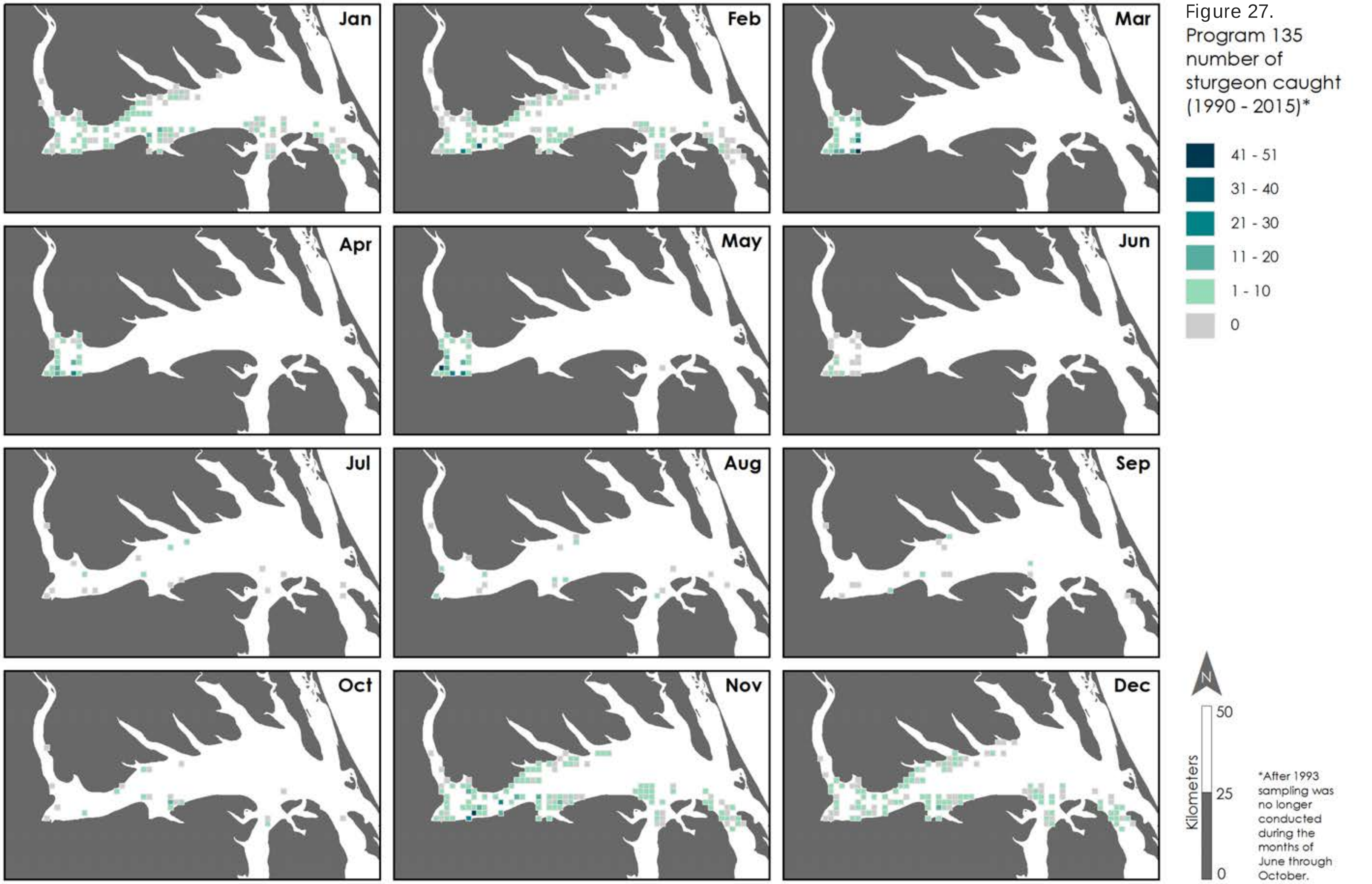


Figure 27. Program 135 number of sturgeon caught (1990 - 2015)*

*After 1993 sampling was no longer conducted during the months of June through October.

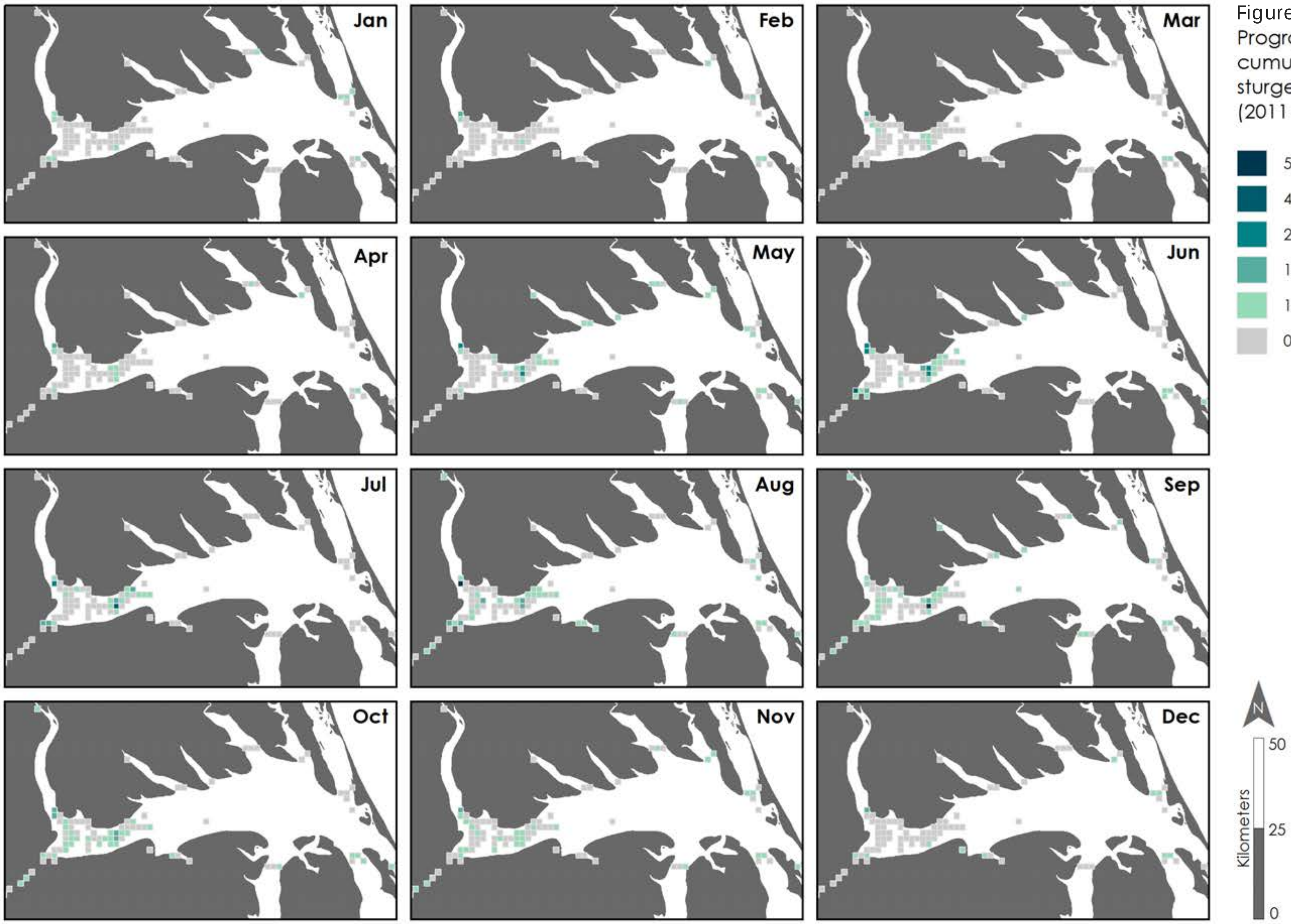


Figure 28.
Program 356
cumulative
sturgeon days
(2011 - 2015)

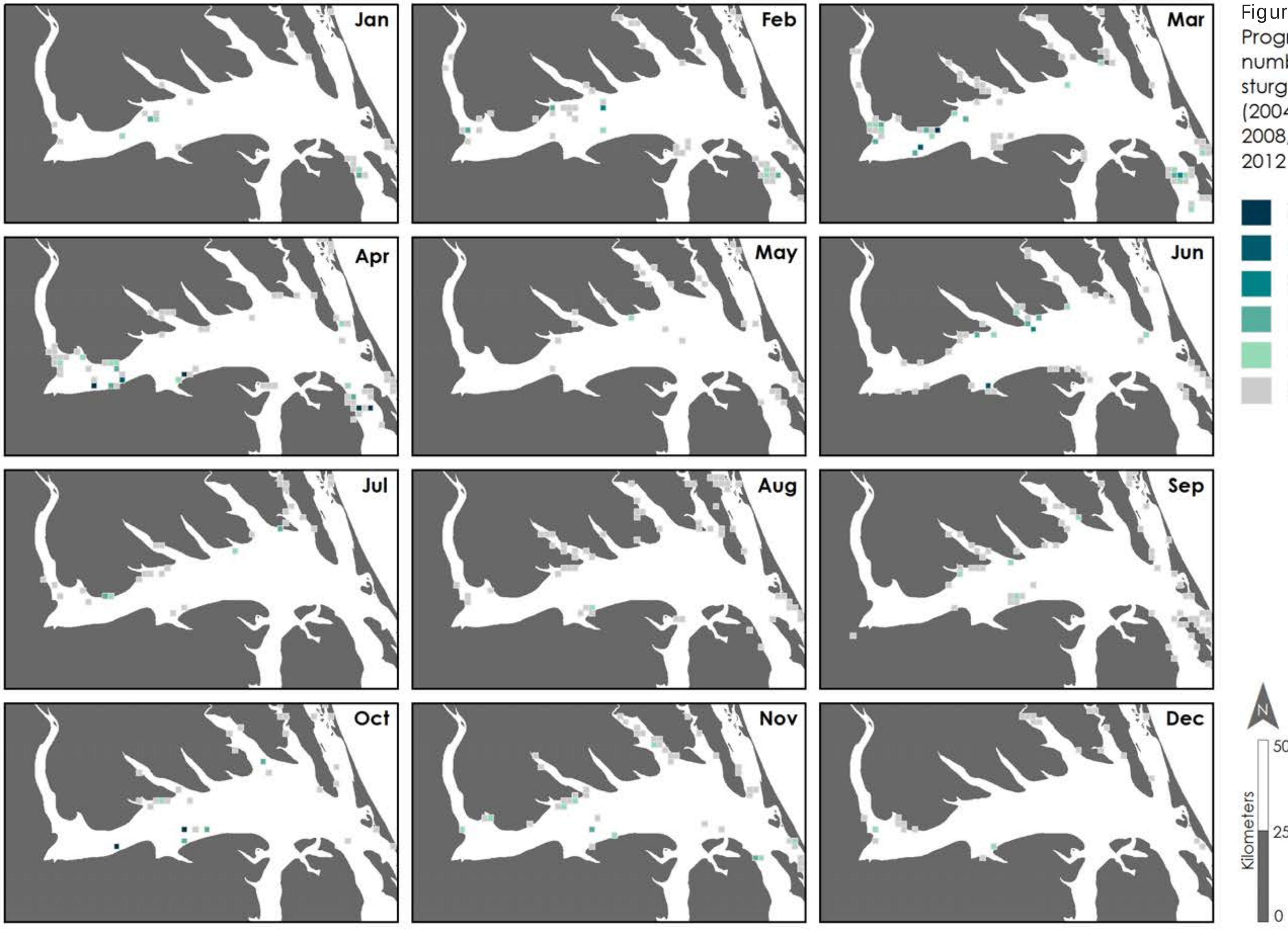


Figure 29. Program 466 number of sturgeon caught (2004 - 2006, 2008, & 2012 - 2014)

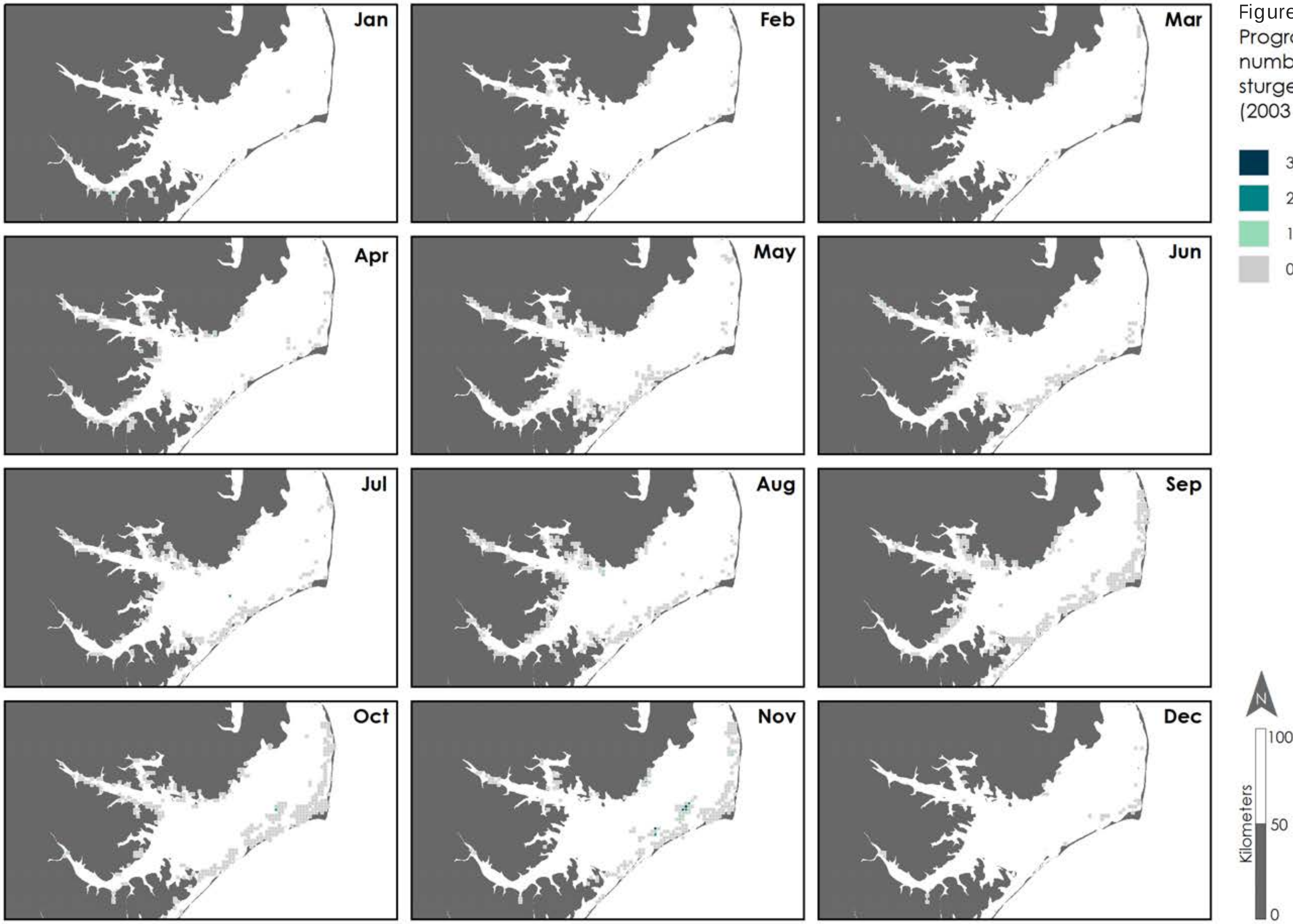


Figure 30.
Program 466
number of
sturgeon caught
(2003 - 2014)

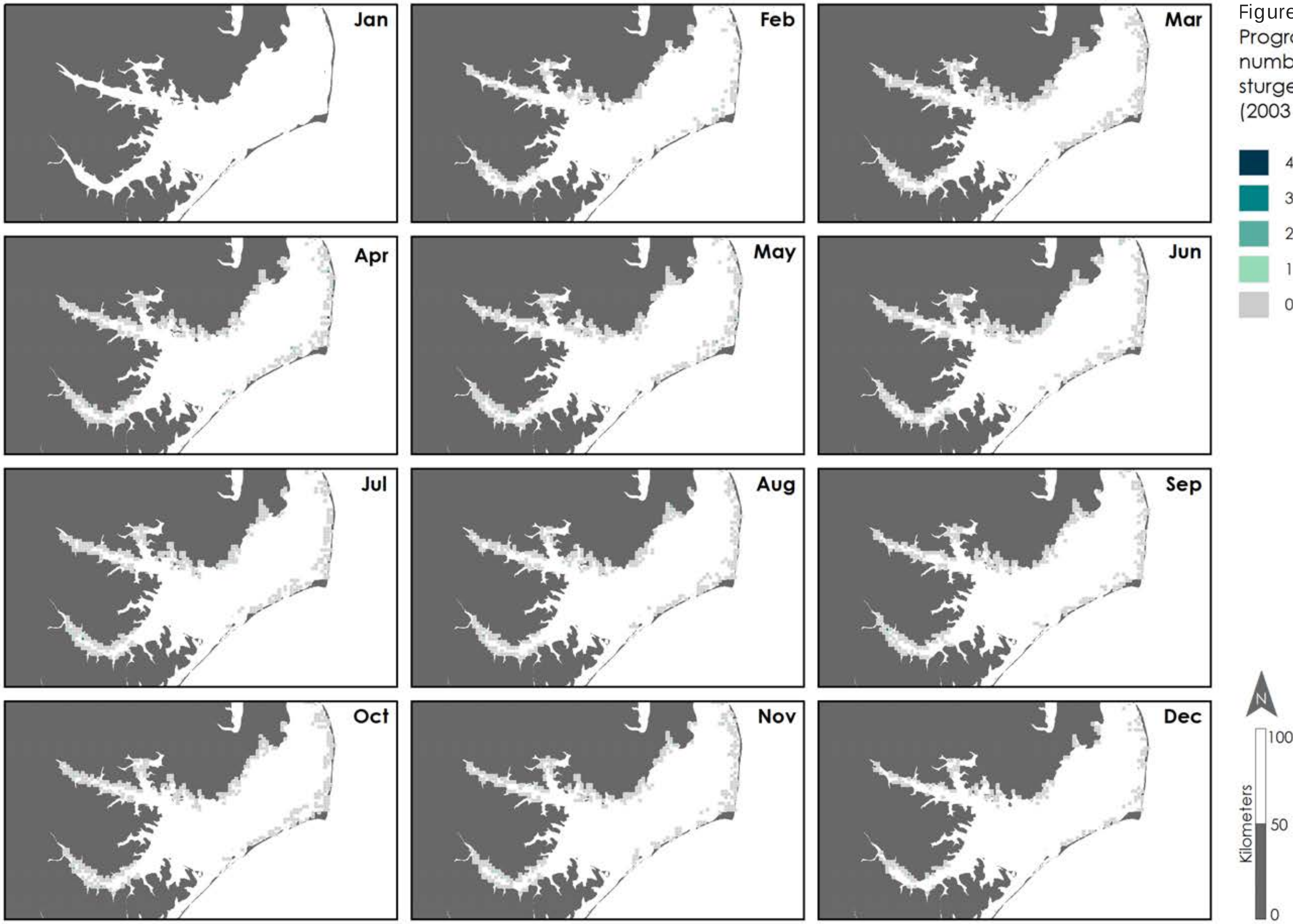


Figure 31.
Program 915 number of sturgeon caught (2003 - 2014)

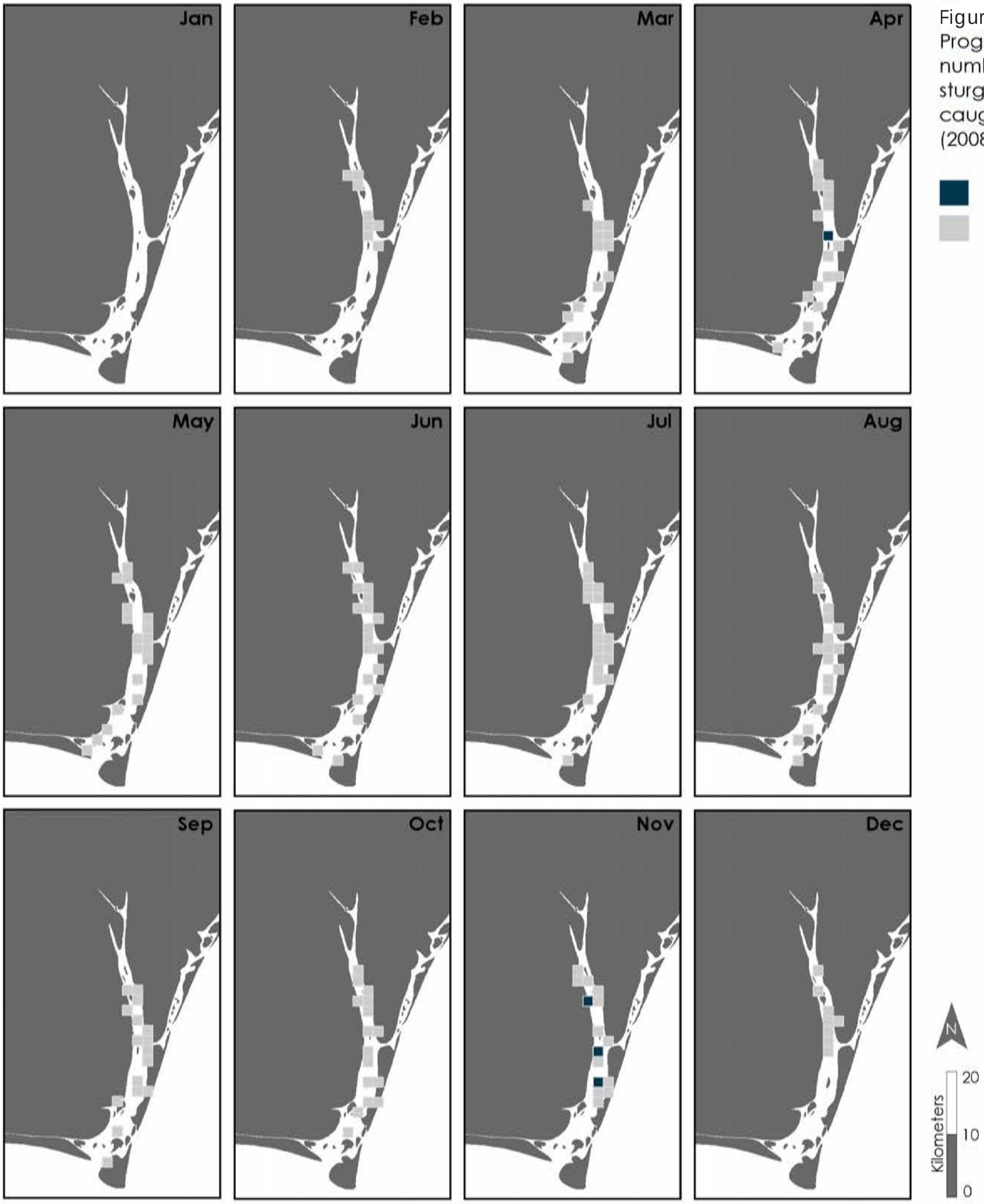


Figure 32. Program 915 number of sturgeon caught (2008 - 2014)

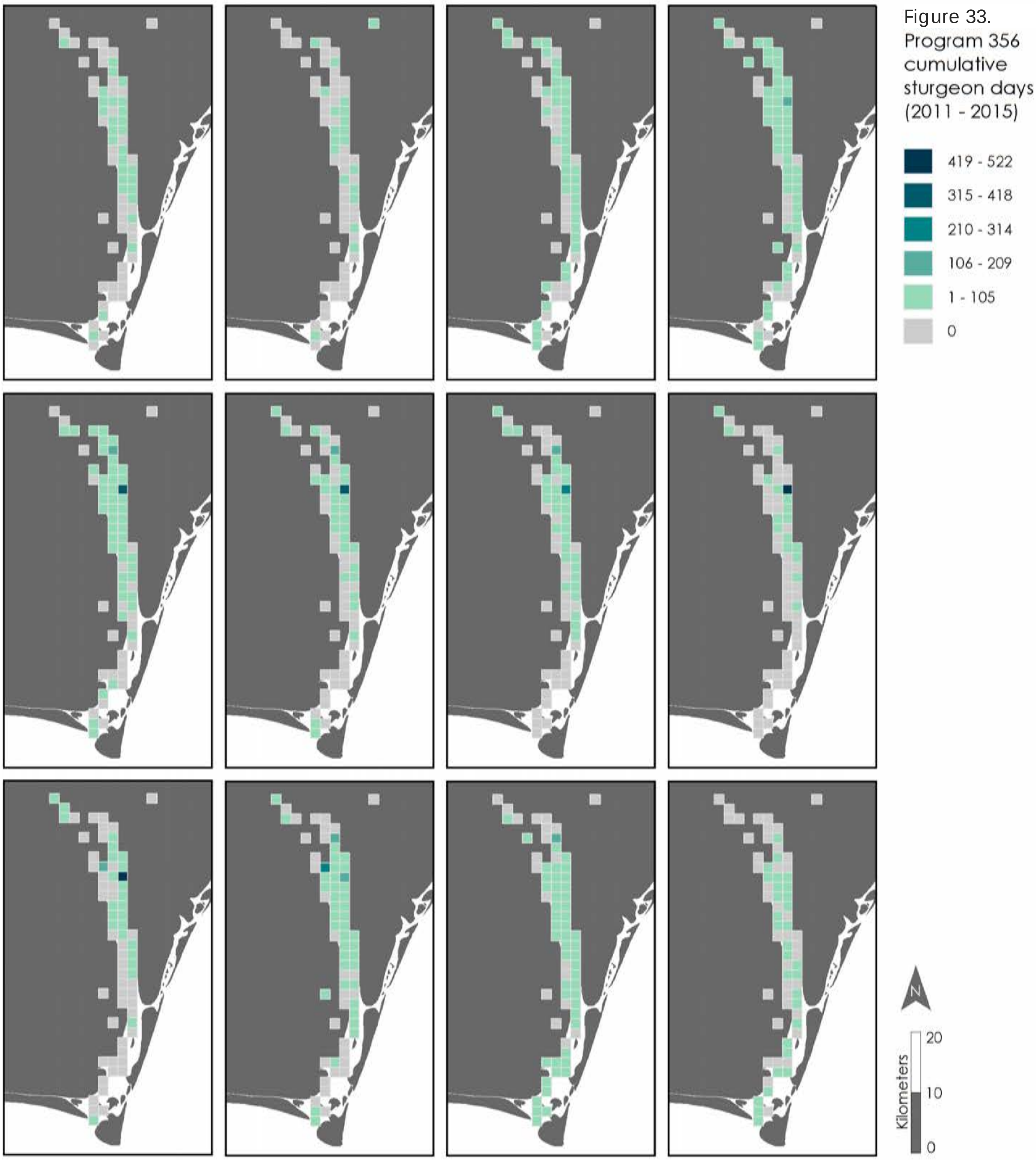


Figure 33. Program 356 cumulative sturgeon days (2011 - 2015)

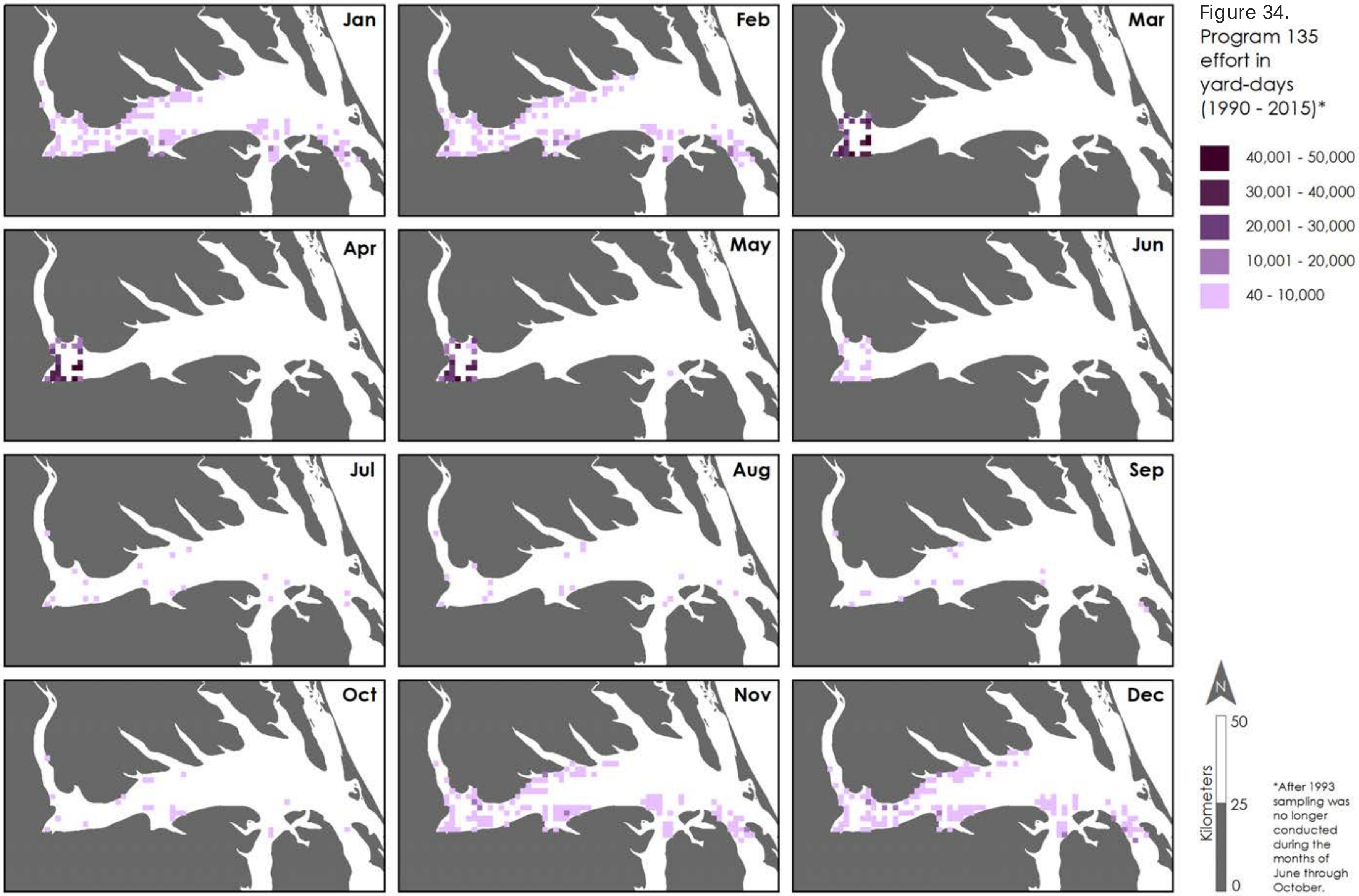


Figure 34. Program 135 effort in yard-days (1990 - 2015)*

*After 1993 sampling was no longer conducted during the months of June through October.

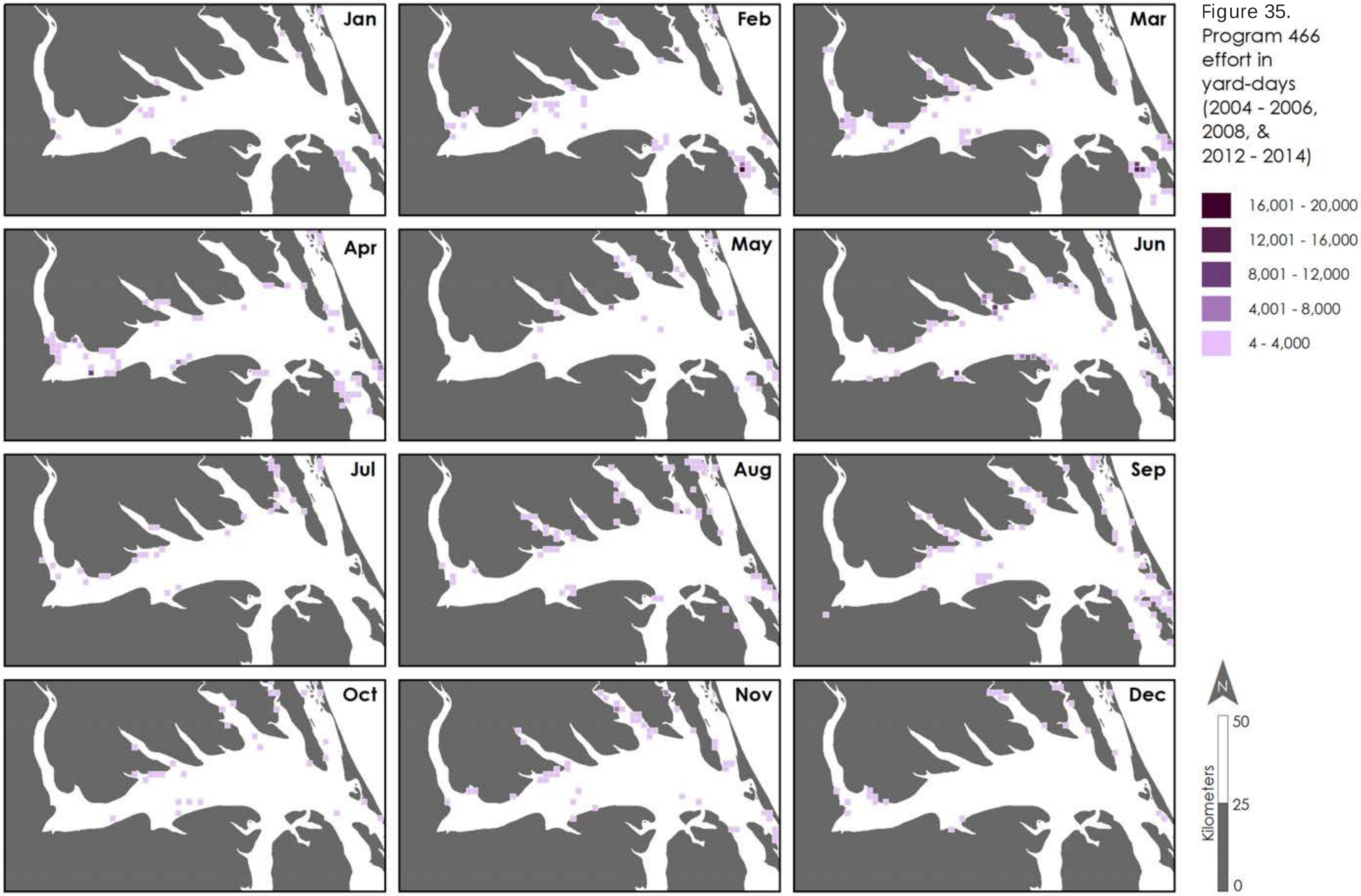


Figure 35. Program 466 effort in yard-days (2004 - 2006, 2008, & 2012 - 2014)

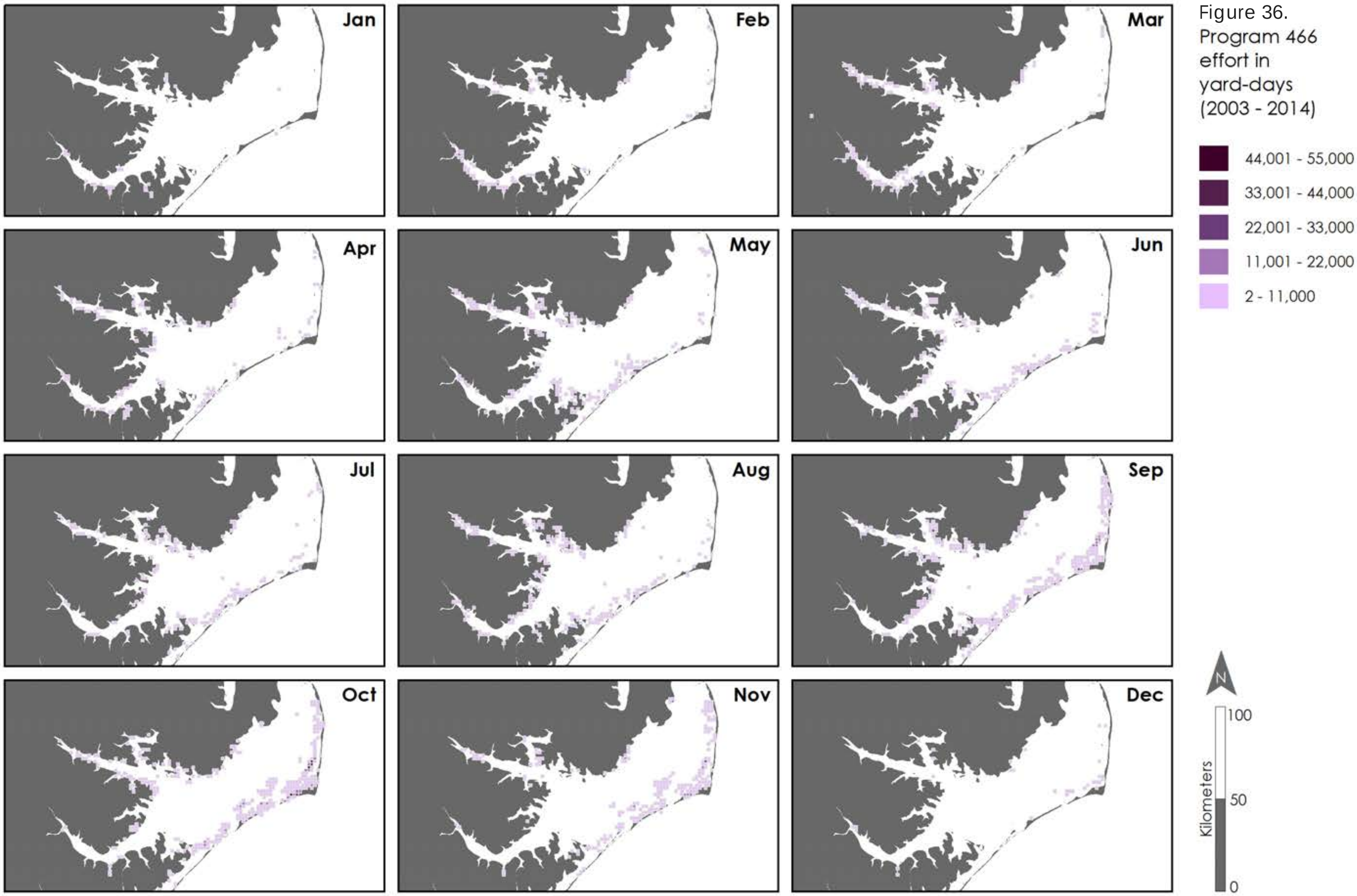


Figure 36. Program 466 effort in yard-days (2003 - 2014)

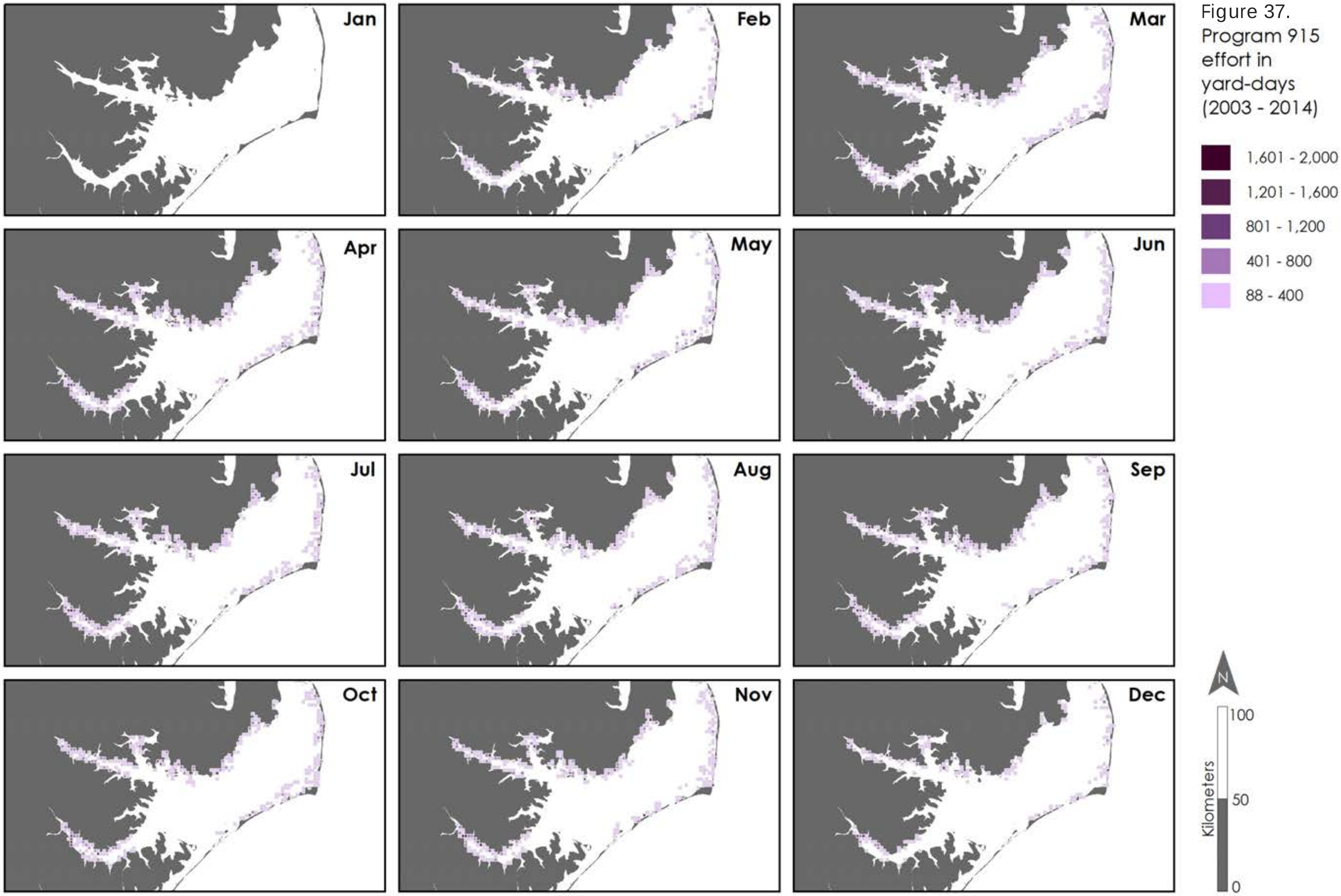


Figure 37. Program 915 effort in yard-days (2003 - 2014)

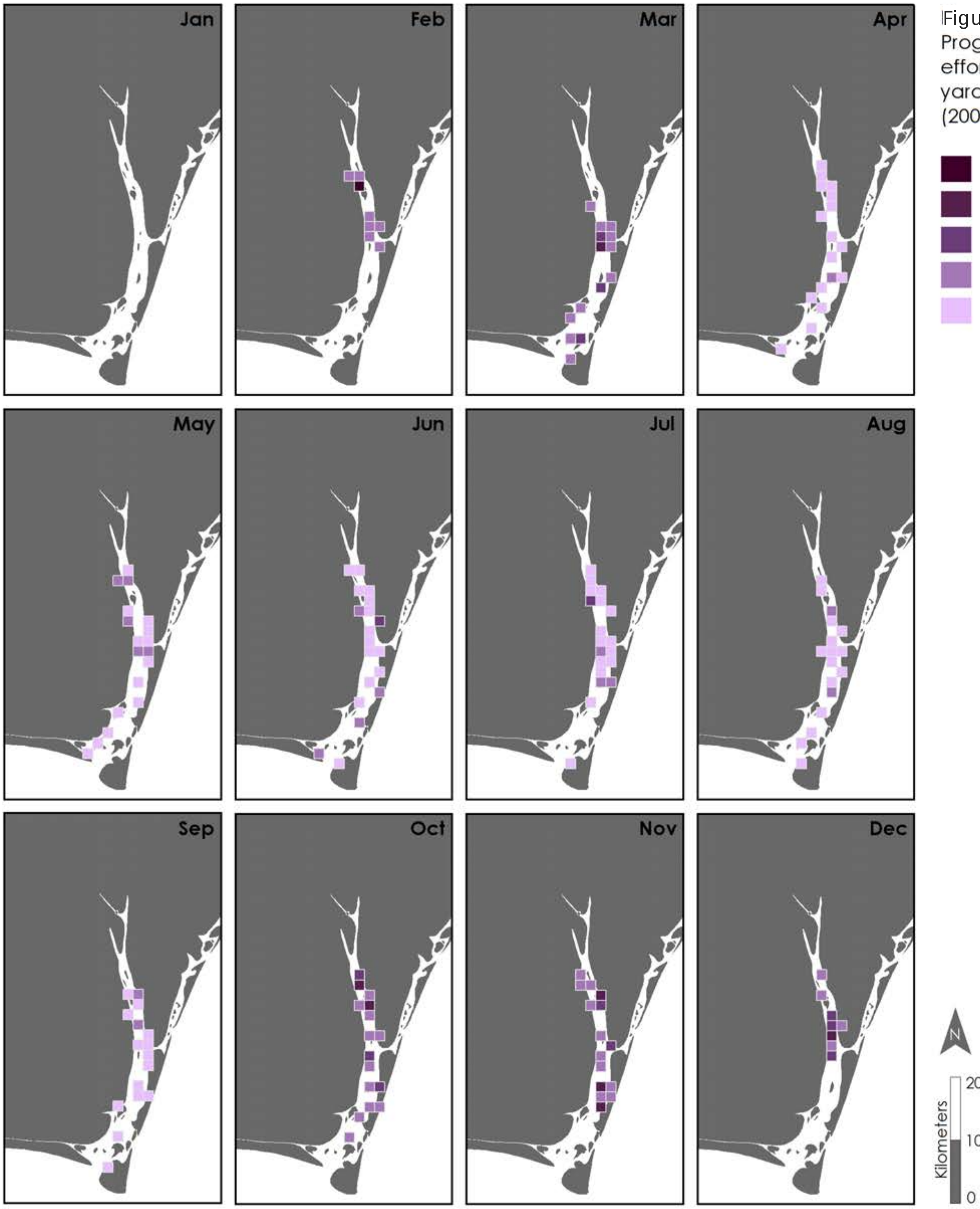


Figure 38. Program 915 effort in yard-days (2008 - 2014)

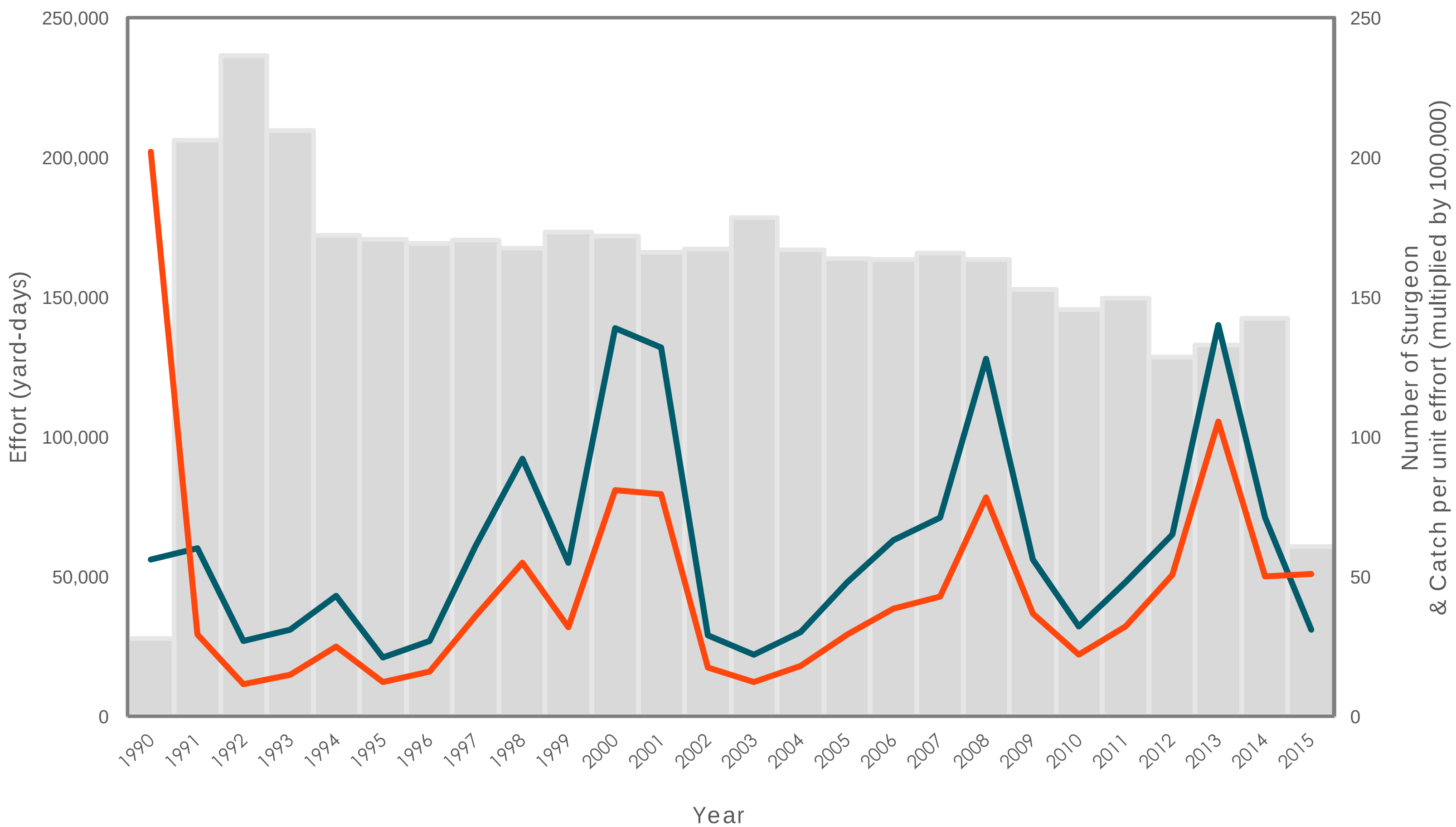


Figure 39. Albemarle Sound Program 135 yearly effort and sturgeon catch

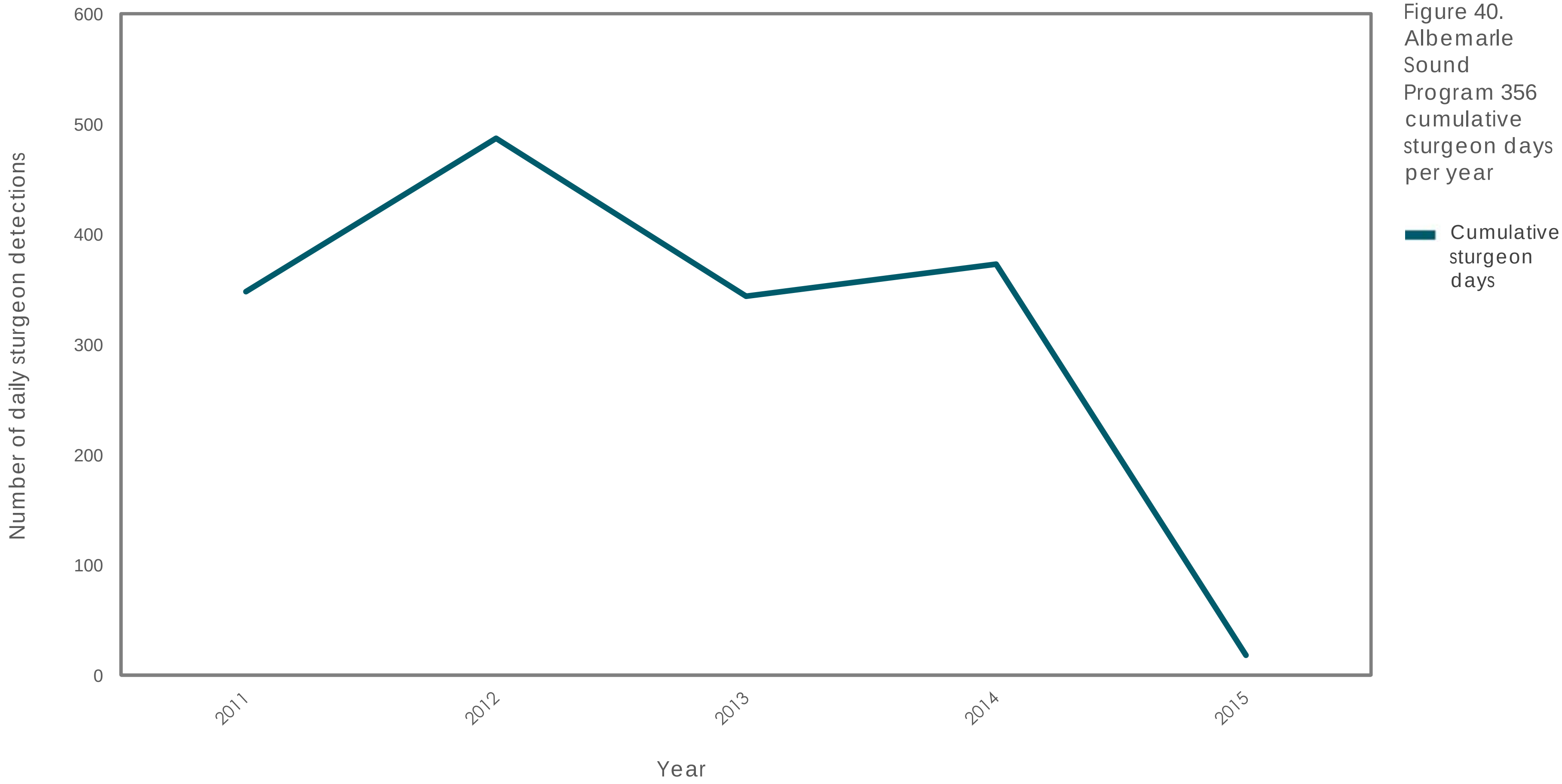


Figure 40. Albemarle Sound Program 356 cumulative sturgeon days per year

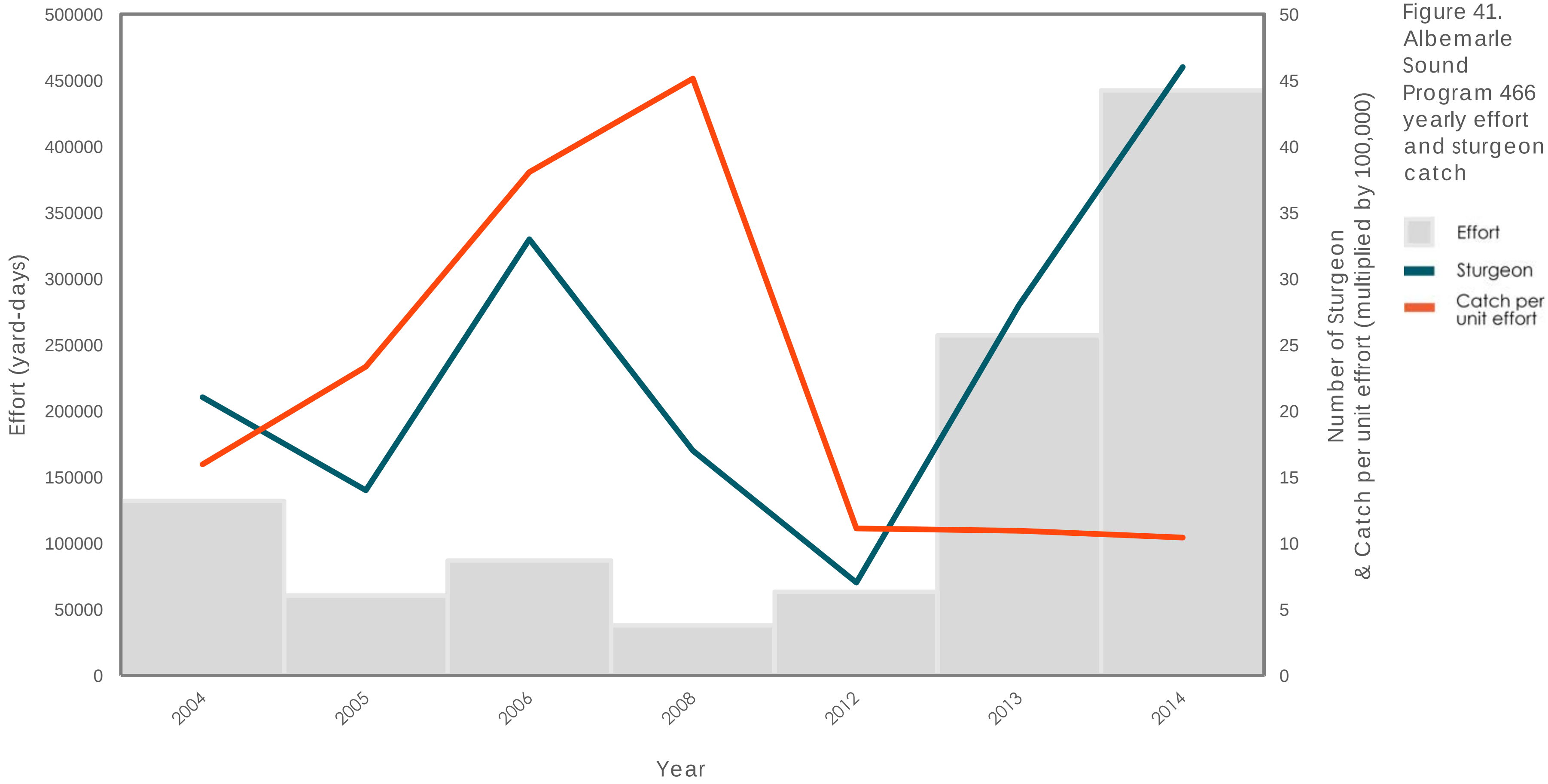


Figure 41. Albemarle Sound Program 466 yearly effort and sturgeon catch

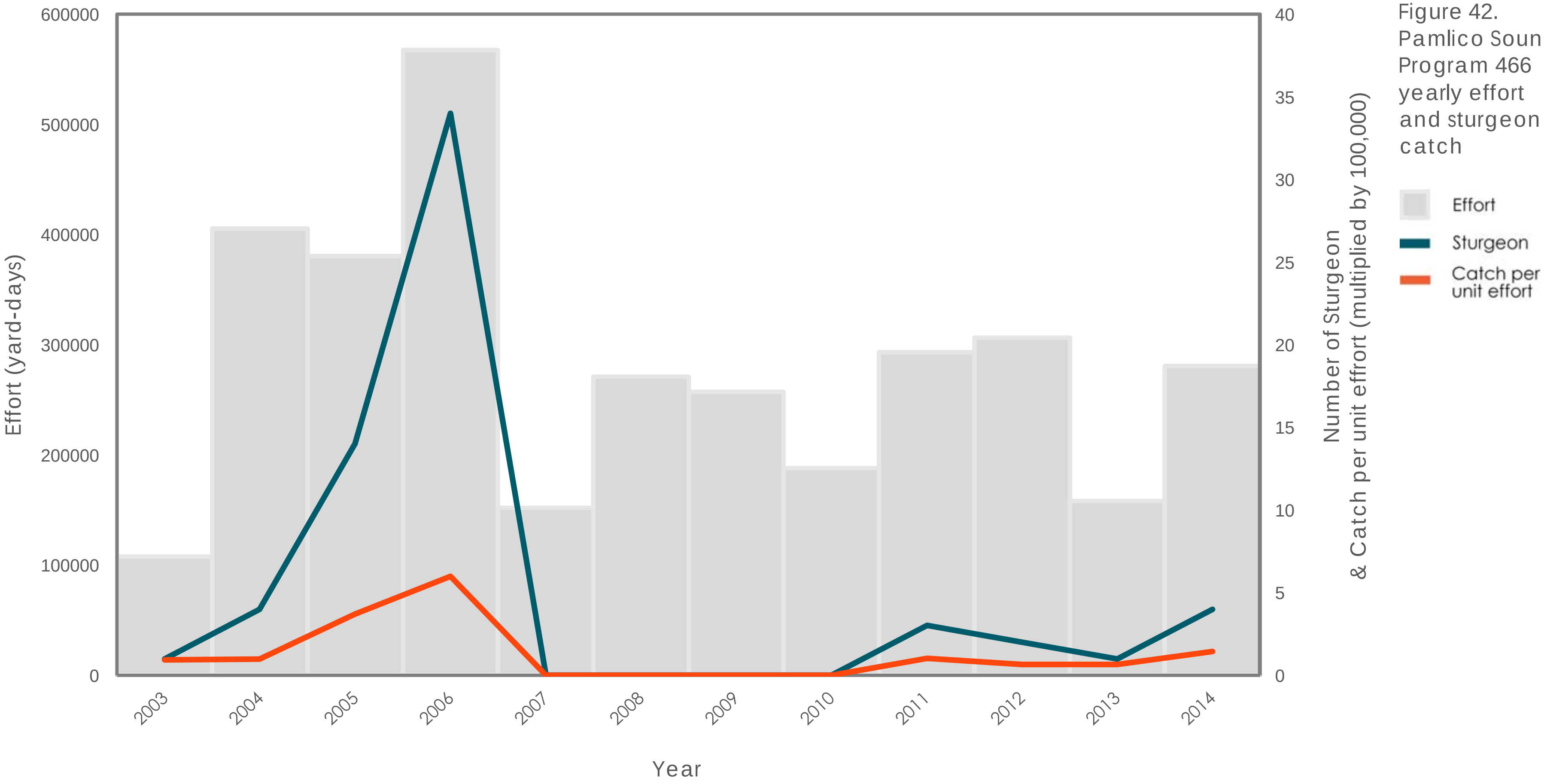


Figure 42. Pamlico Sound Program 466 yearly effort and sturgeon catch

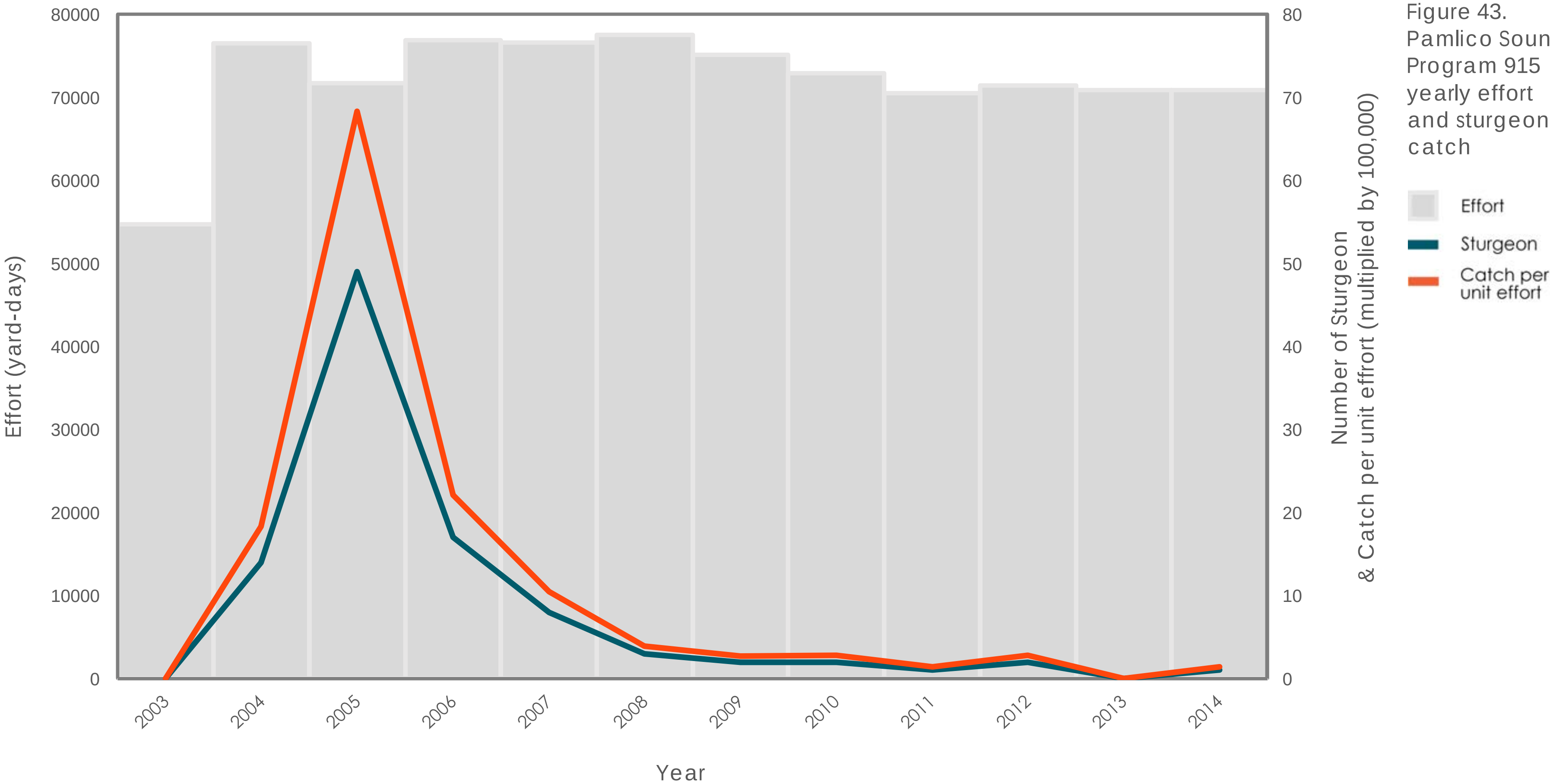


Figure 43. Pamlico Sound Program 915 yearly effort and sturgeon catch

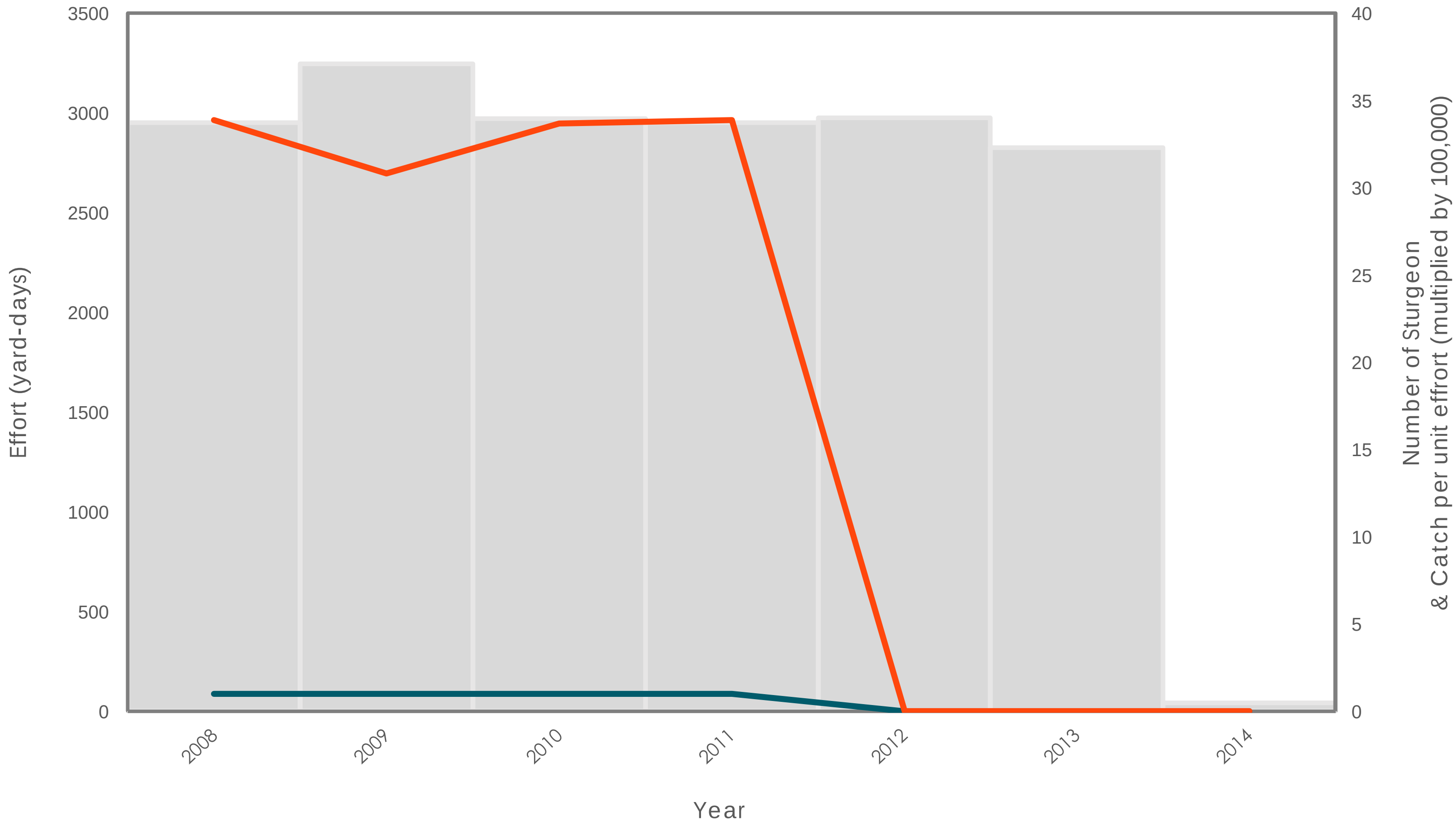


Figure 44. Cape Fear Program 915 yearly effort and sturgeon catch

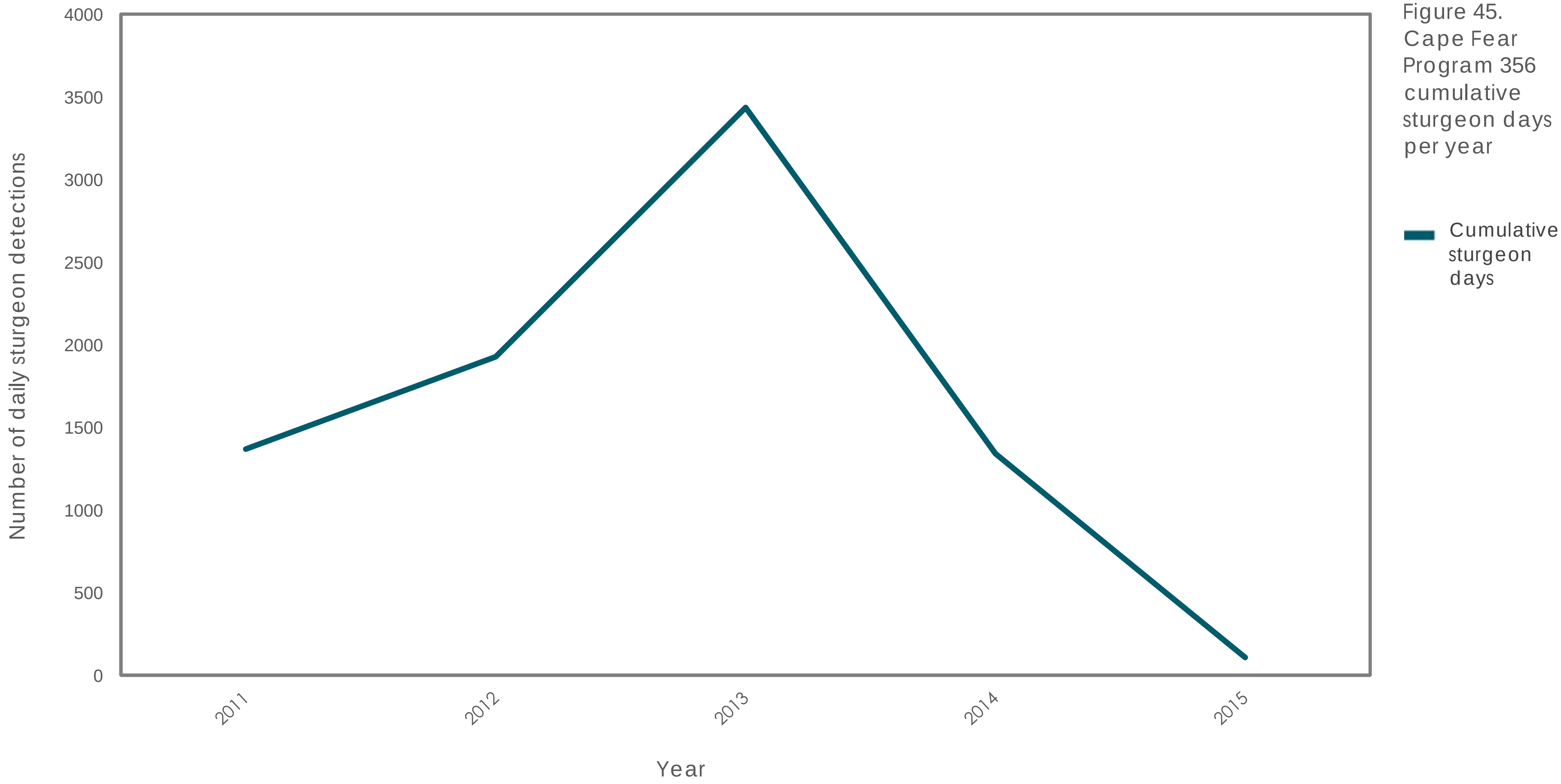


Figure 45. Cape Fear Program 356 cumulative sturgeon days per year

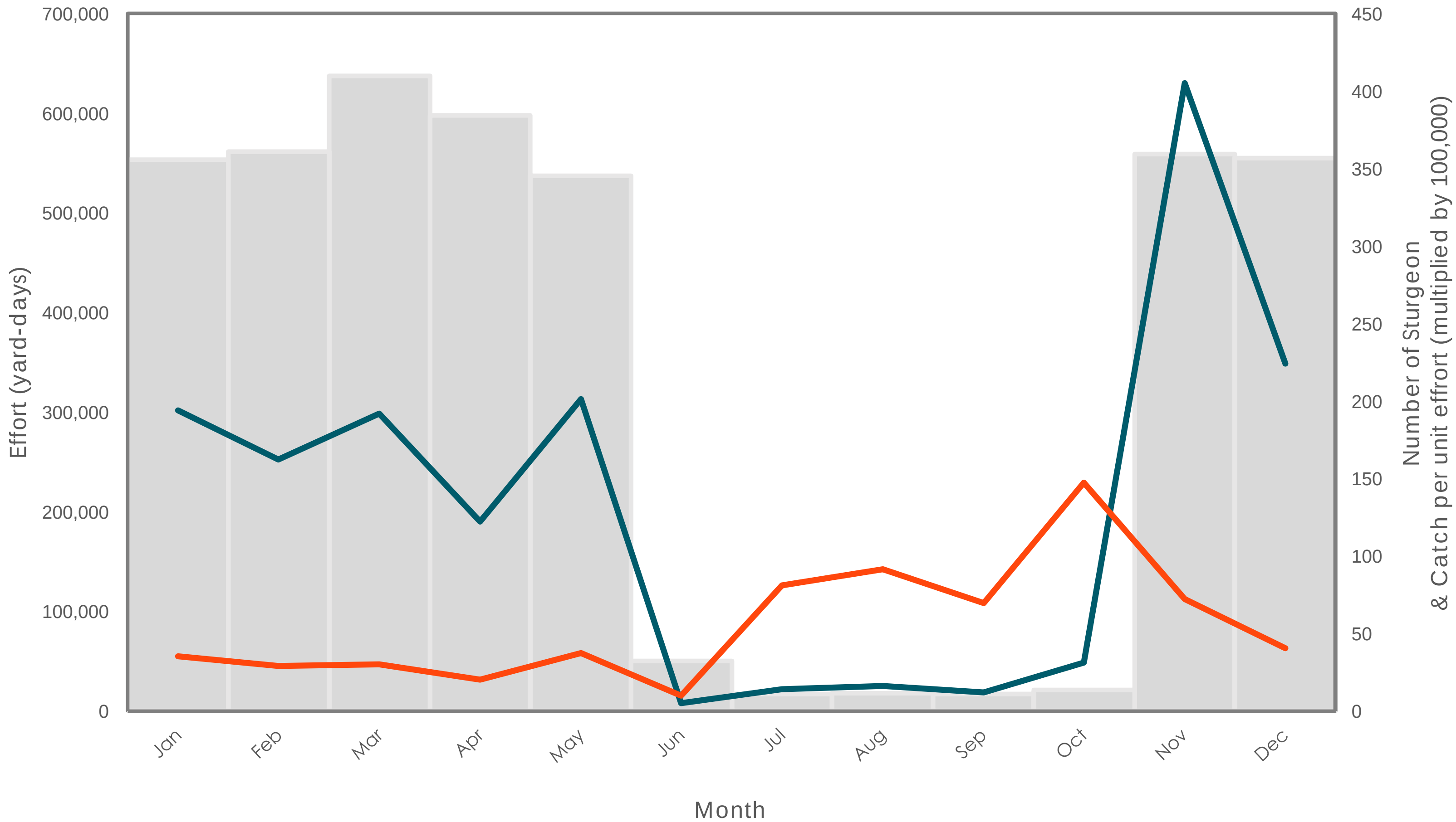


Figure 46. Albemarle Sound Program 135 monthly effort and sturgeon catch

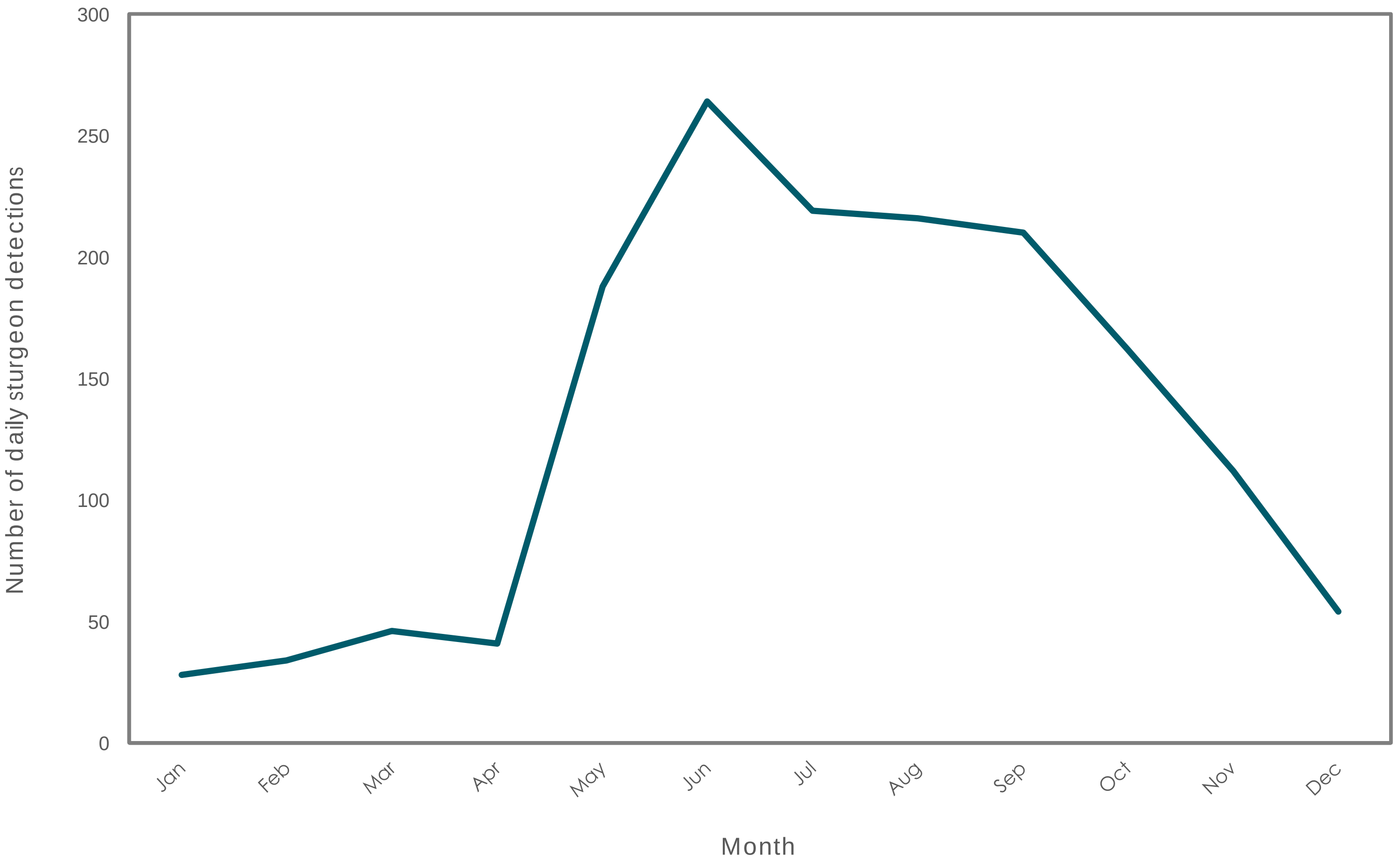


Figure 47. Albemarle Sound Program 356 cumulative sturgeon days per month

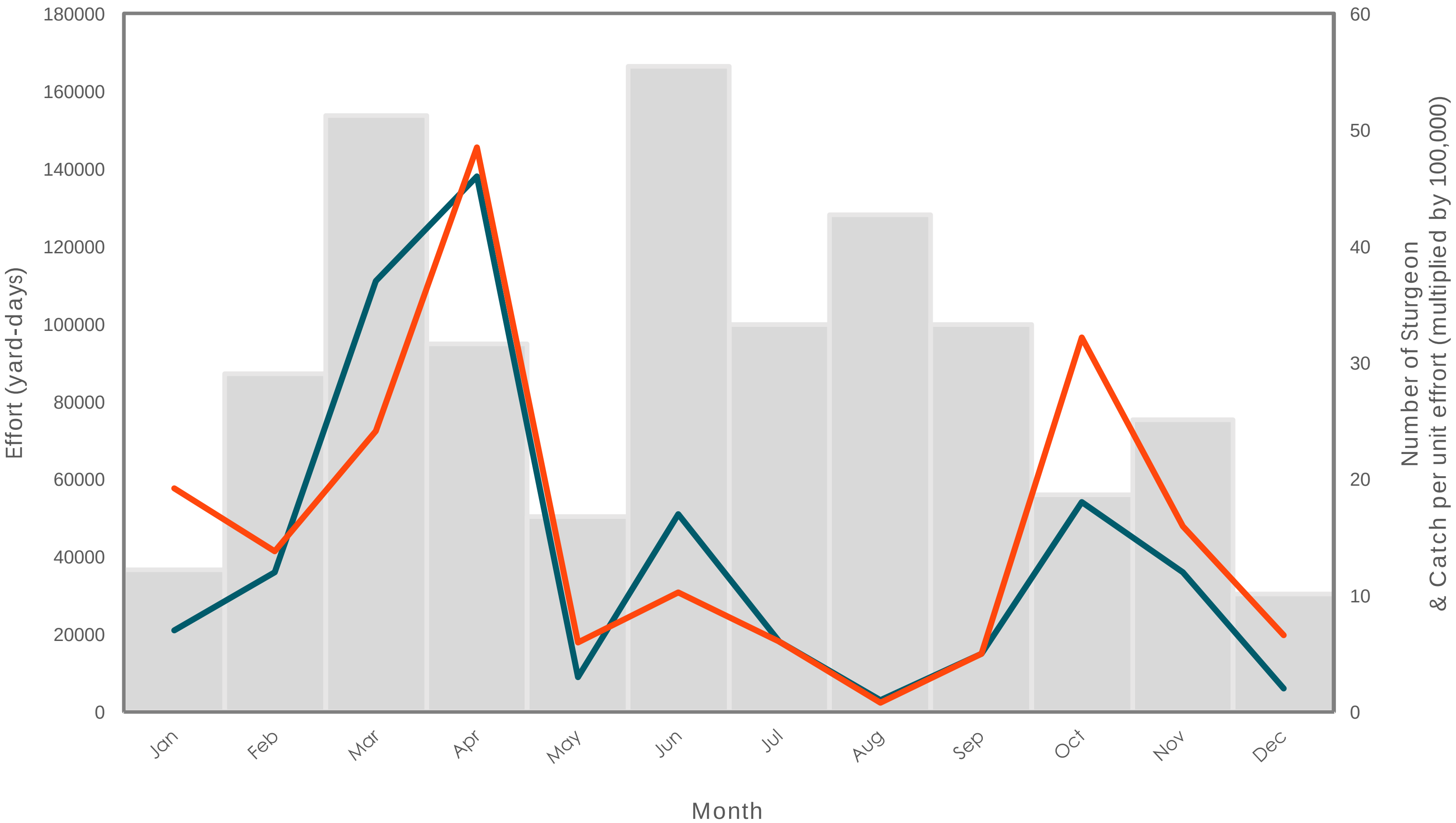


Figure 48. Albemarle Sound Program 466 monthly effort and sturgeon catch

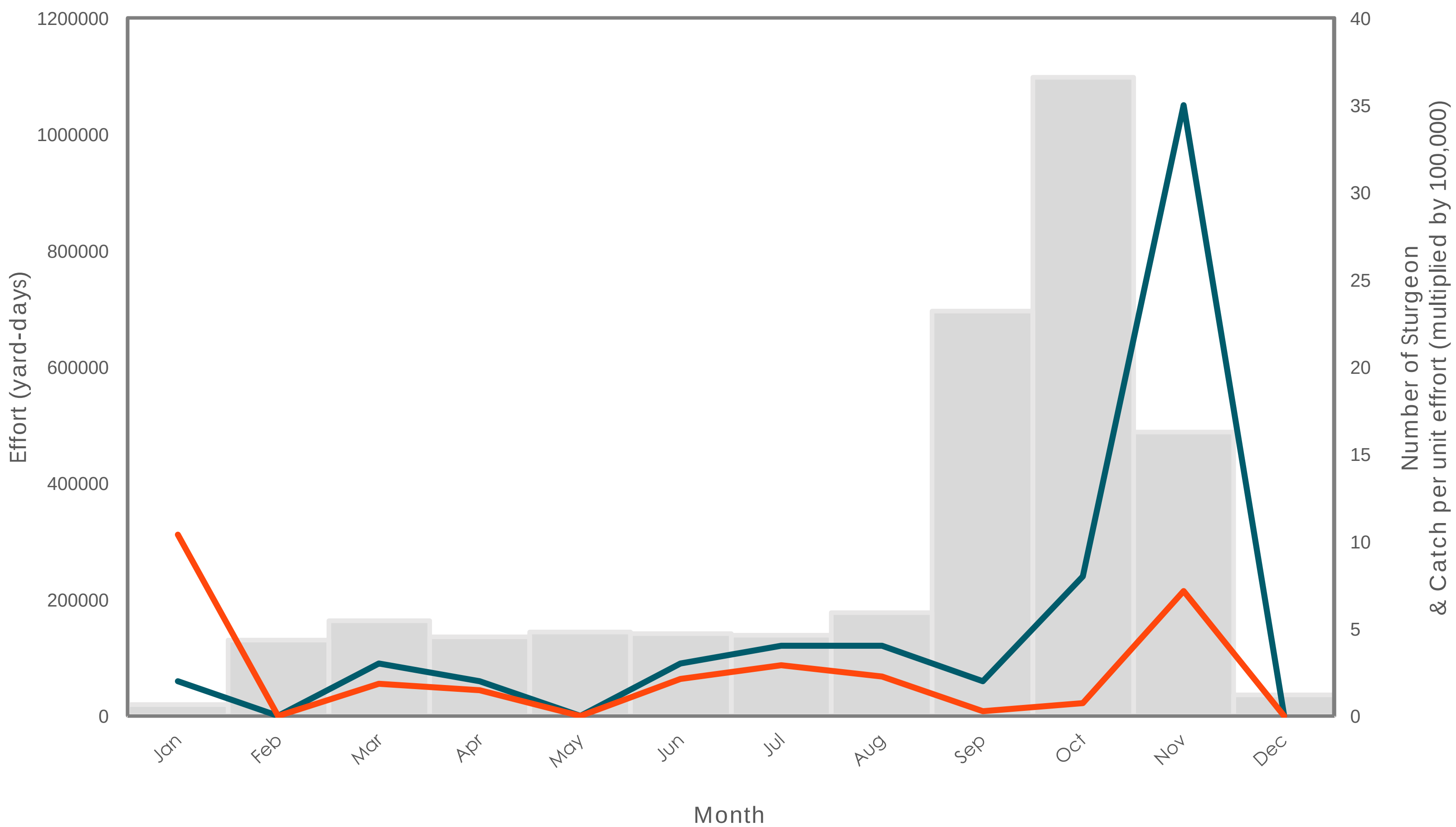


Figure 49. Pamlico Sound Program 466 monthly effort and sturgeon catch

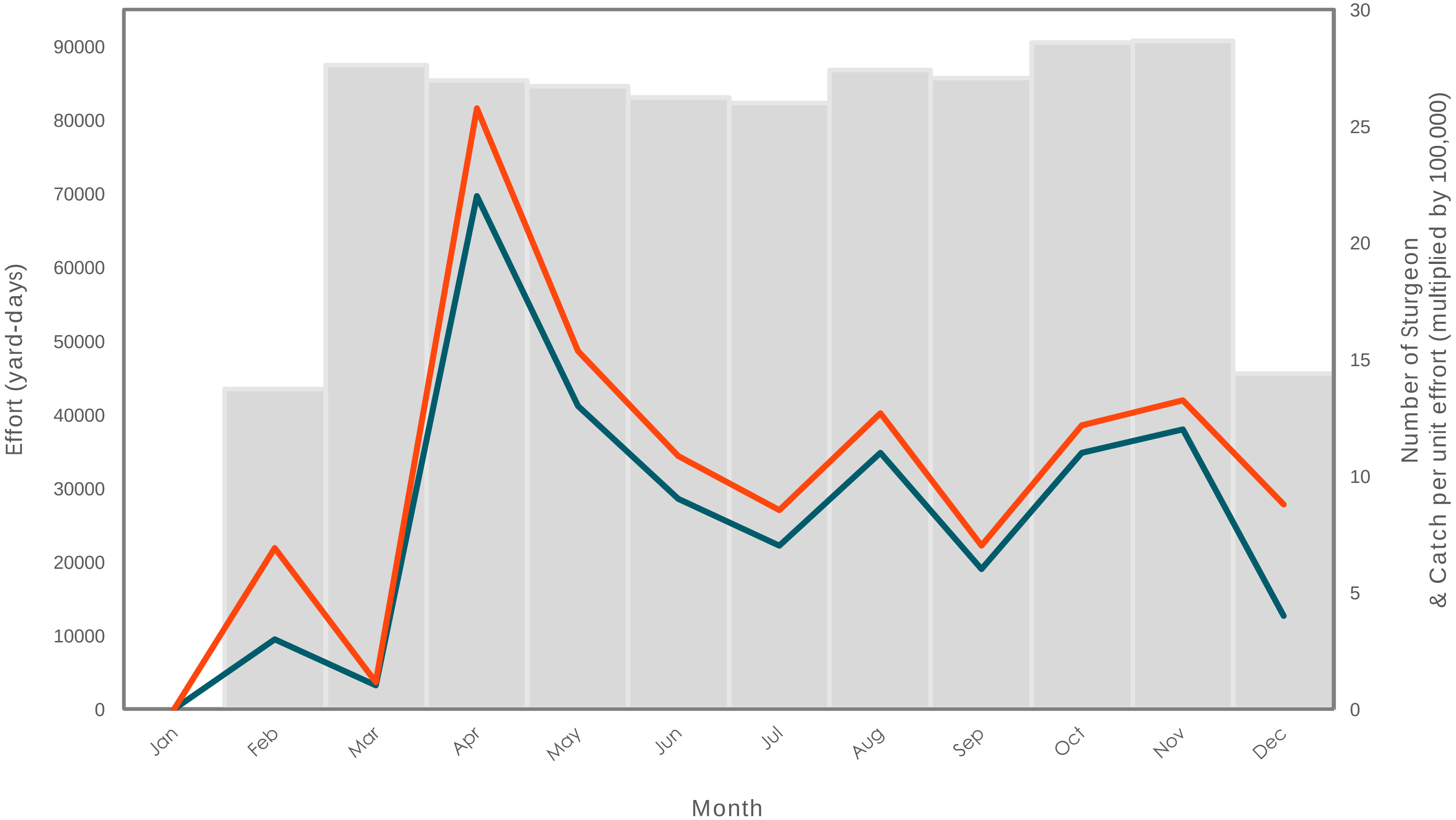


Figure 50. Pamlico Sound Program 915 monthly effort and sturgeon catch

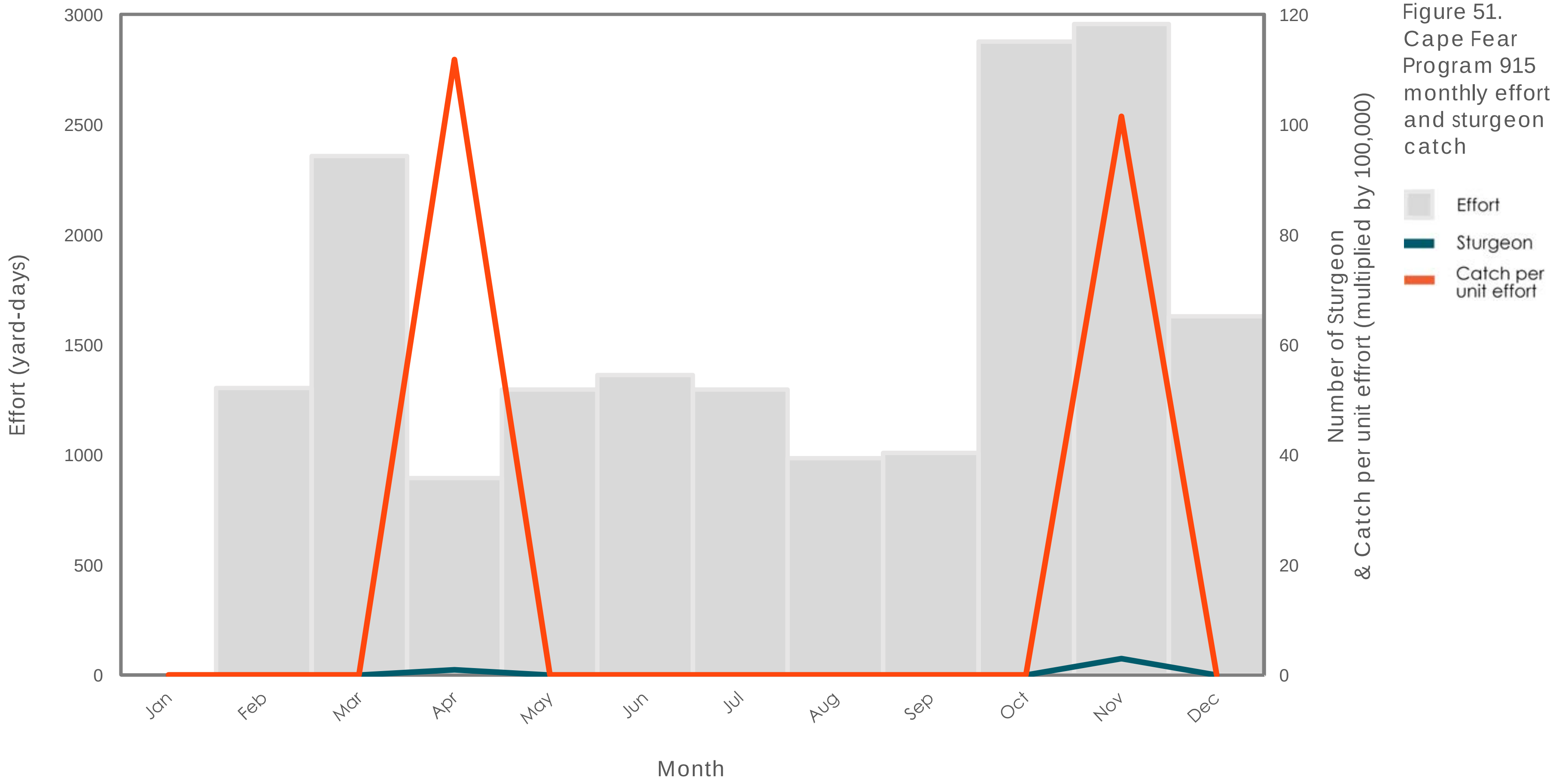


Figure 51. Cape Fear Program 915 monthly effort and sturgeon catch

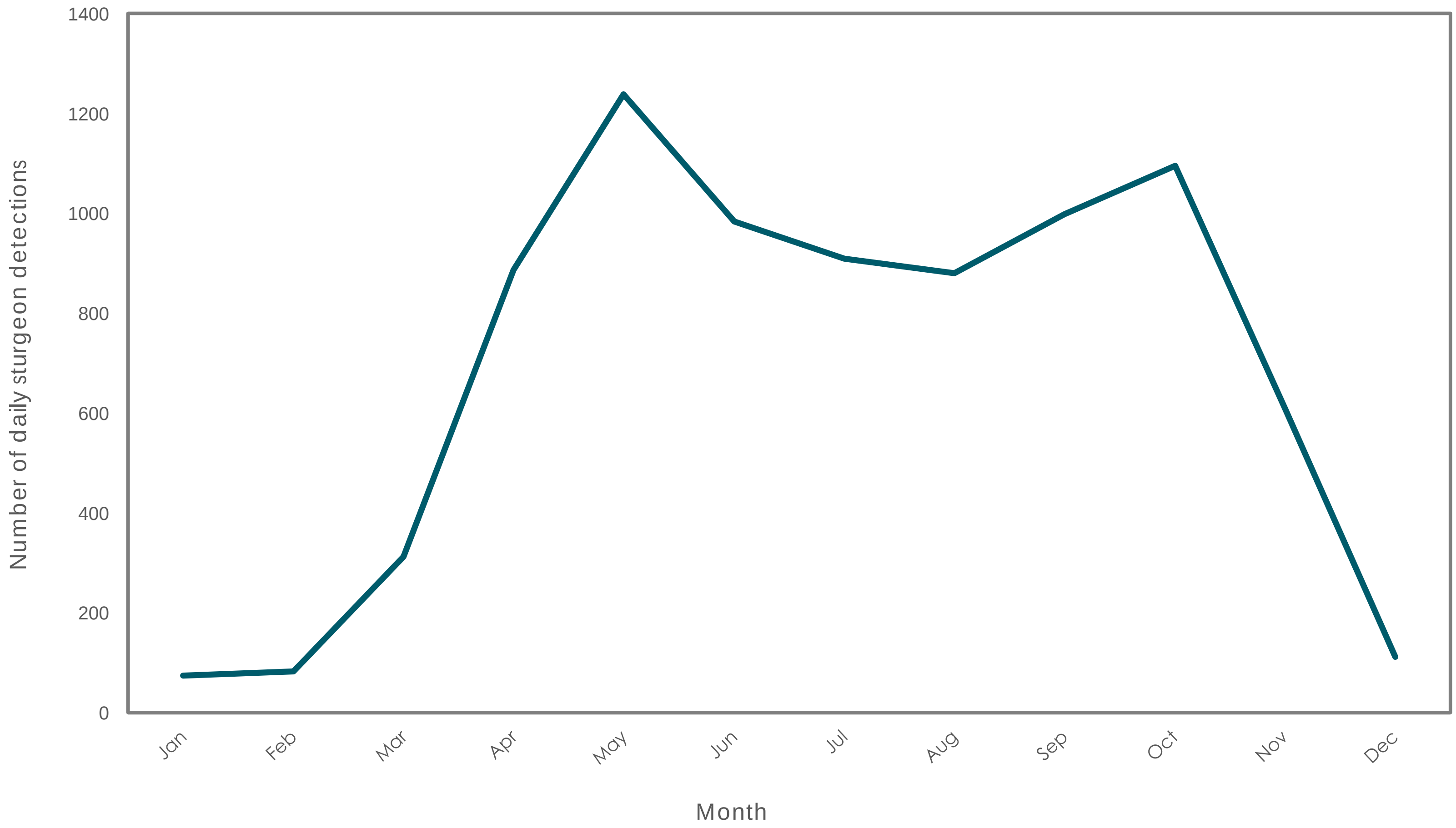


Figure 52. Cape Fear Program 356 cumulative sturgeon days per month

MERGED DATASET MAPS

CATCH PER UNIT EFFORT MERGE - SEASONAL

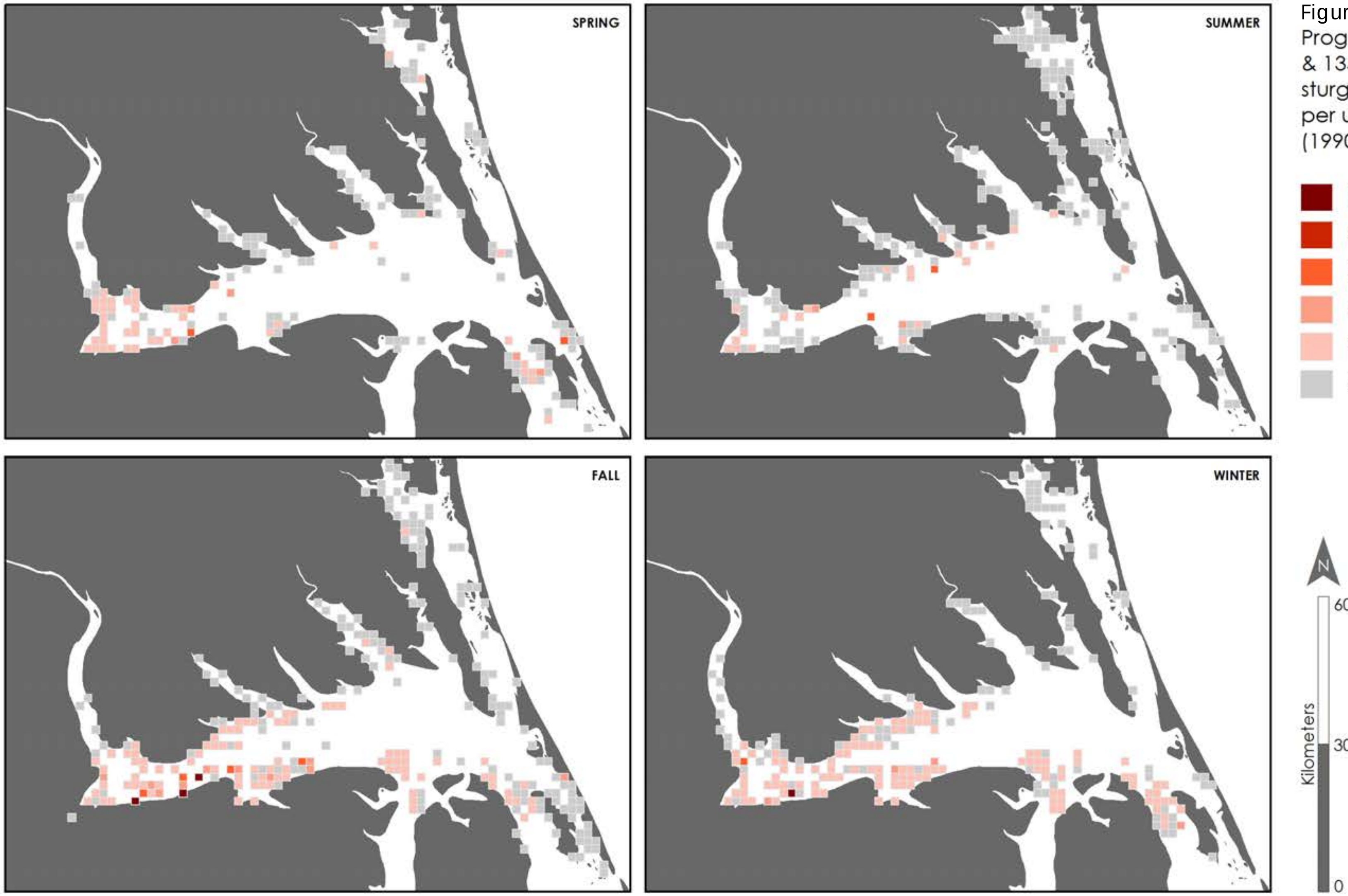


Figure 53. Programs 466 & 135 sturgeon catch per unit effort (1990 - 2015)

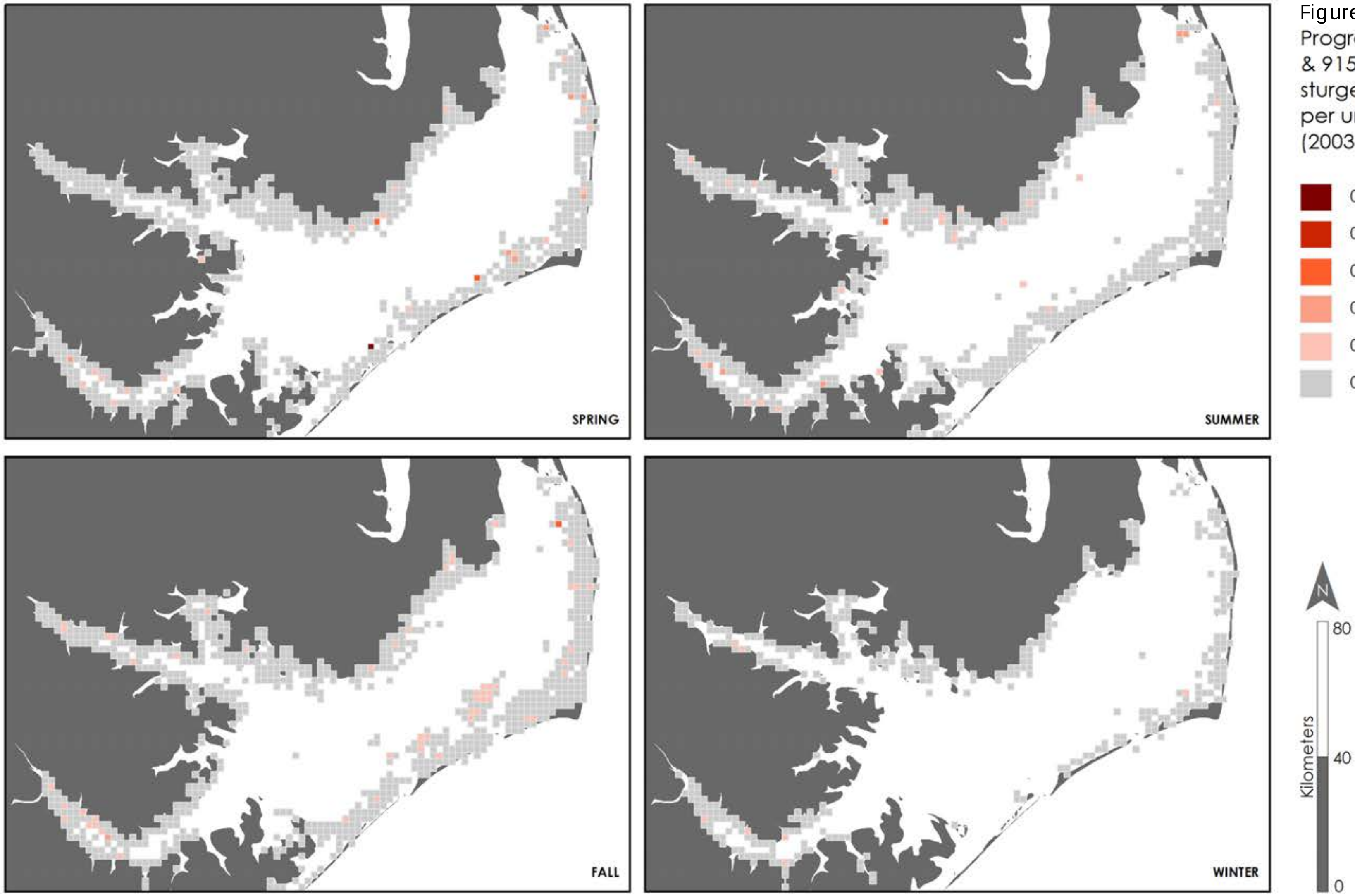


Figure 54.
Program 466
& 915
sturgeon catch
per unit effort
(2003 - 2014)

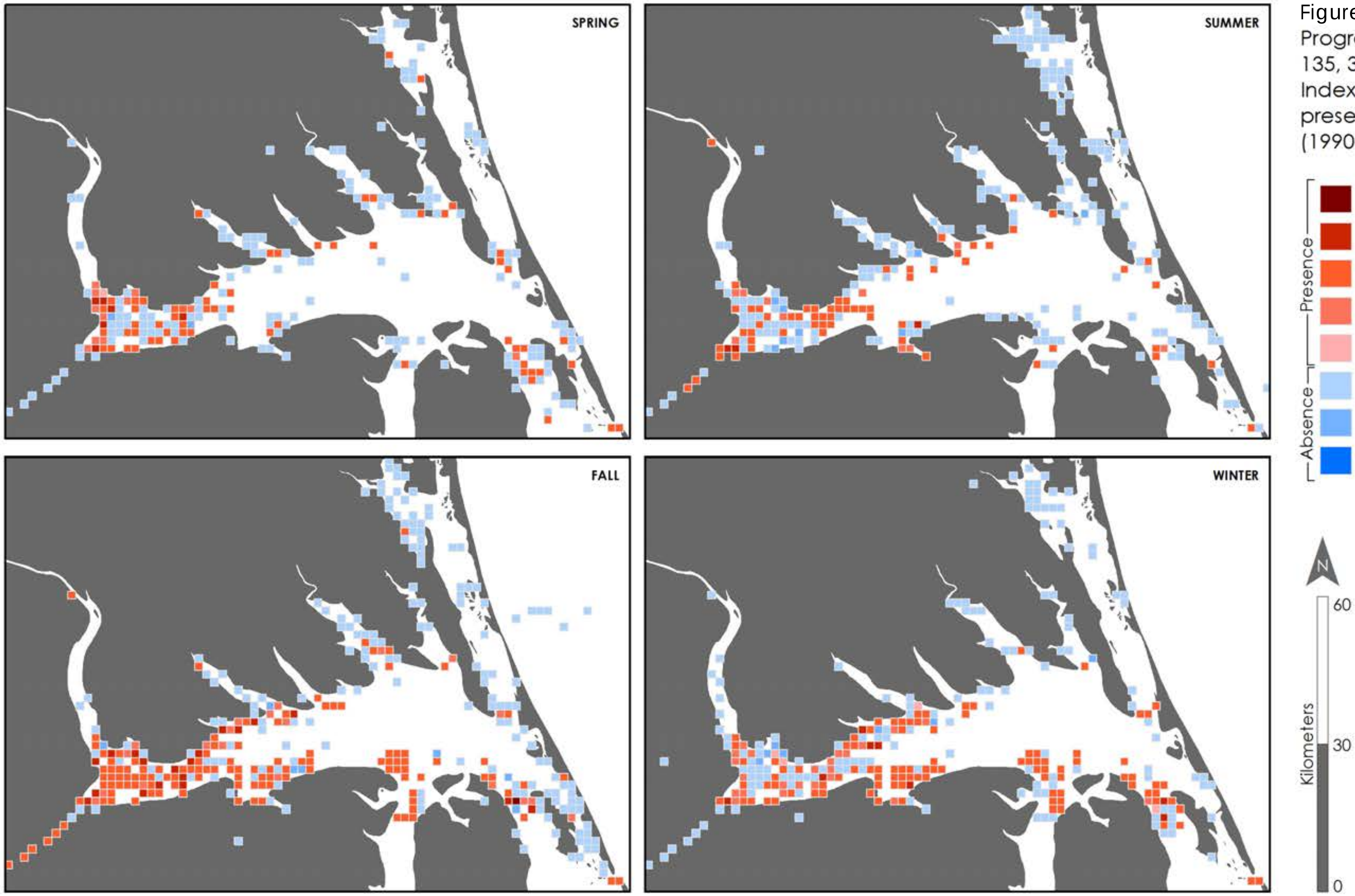


Figure 55.
Programs
135, 356, & 466
Index of sturgeon
presence*
(1990 - 2015)

*This index takes into account whether or not a sturgeon was recorded in a given grid cell for each dataset, as well as the number of datasets for which sampling occured in that grid cell during the given time period. The lowest index value is given to grid cells where an absence was recorded in all three datasets, and the highest index value is given to grid cells where a presence was recorded in all three datasets. See methods section for a more detailed explanation.

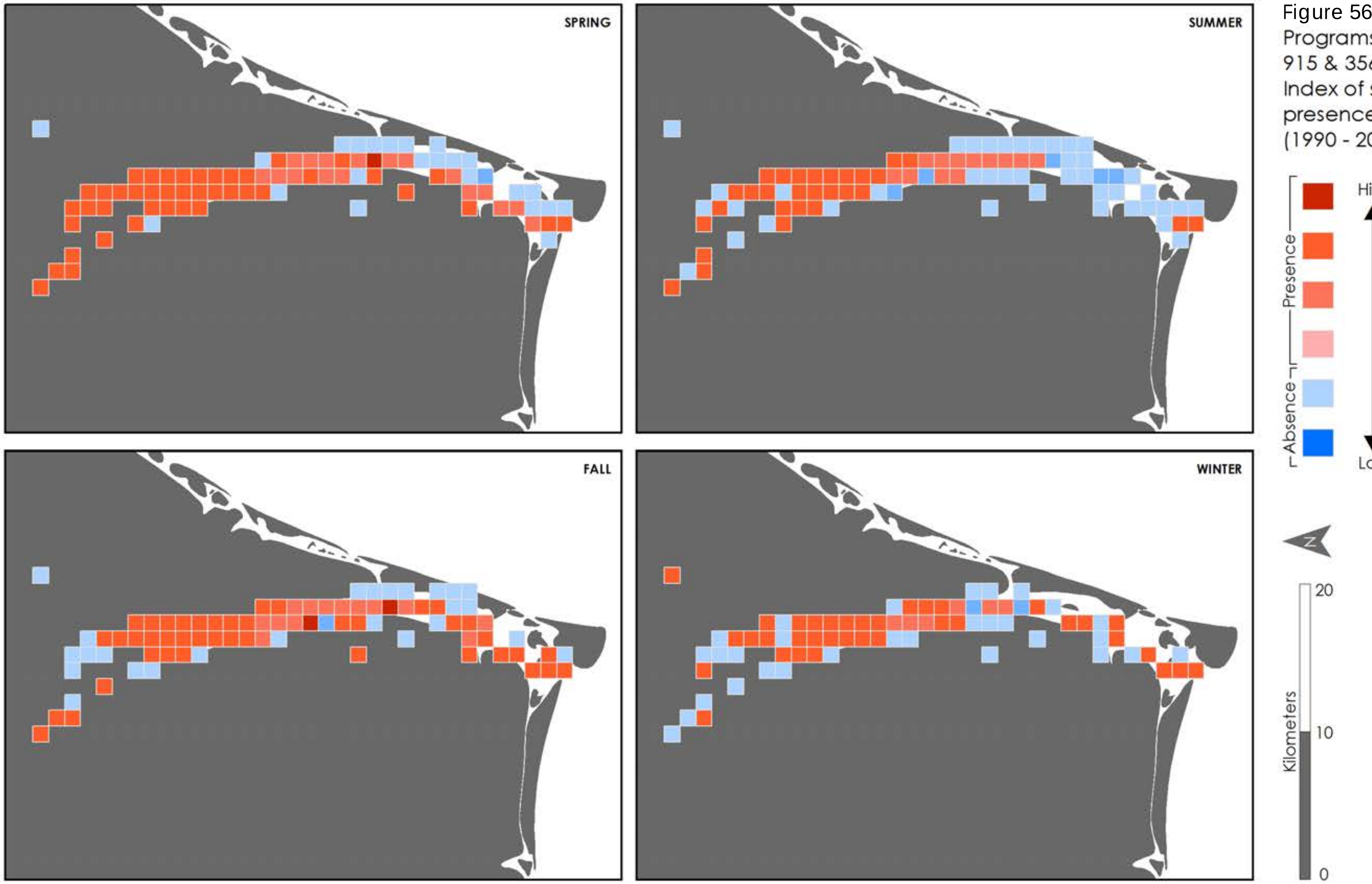


Figure 56.
Programs
915 & 356
Index of sturgeon
presence*
(1990 - 2015)

*This index takes into account whether or not a sturgeon was recorded in a given grid cell for each dataset, as well as the number of datasets for which sampling occured in that grid cell during the given time period. The lowest index value is given to grid cells where an absence was recorded in all three datasets, and the highest index value is given to grid cells where a presence was recorded in all three datasets. See methods section for a more detailed explanation.

CATCH PER UNIT EFFORT MERGE, ONLY COMMON DATE RANGES - SEASONAL

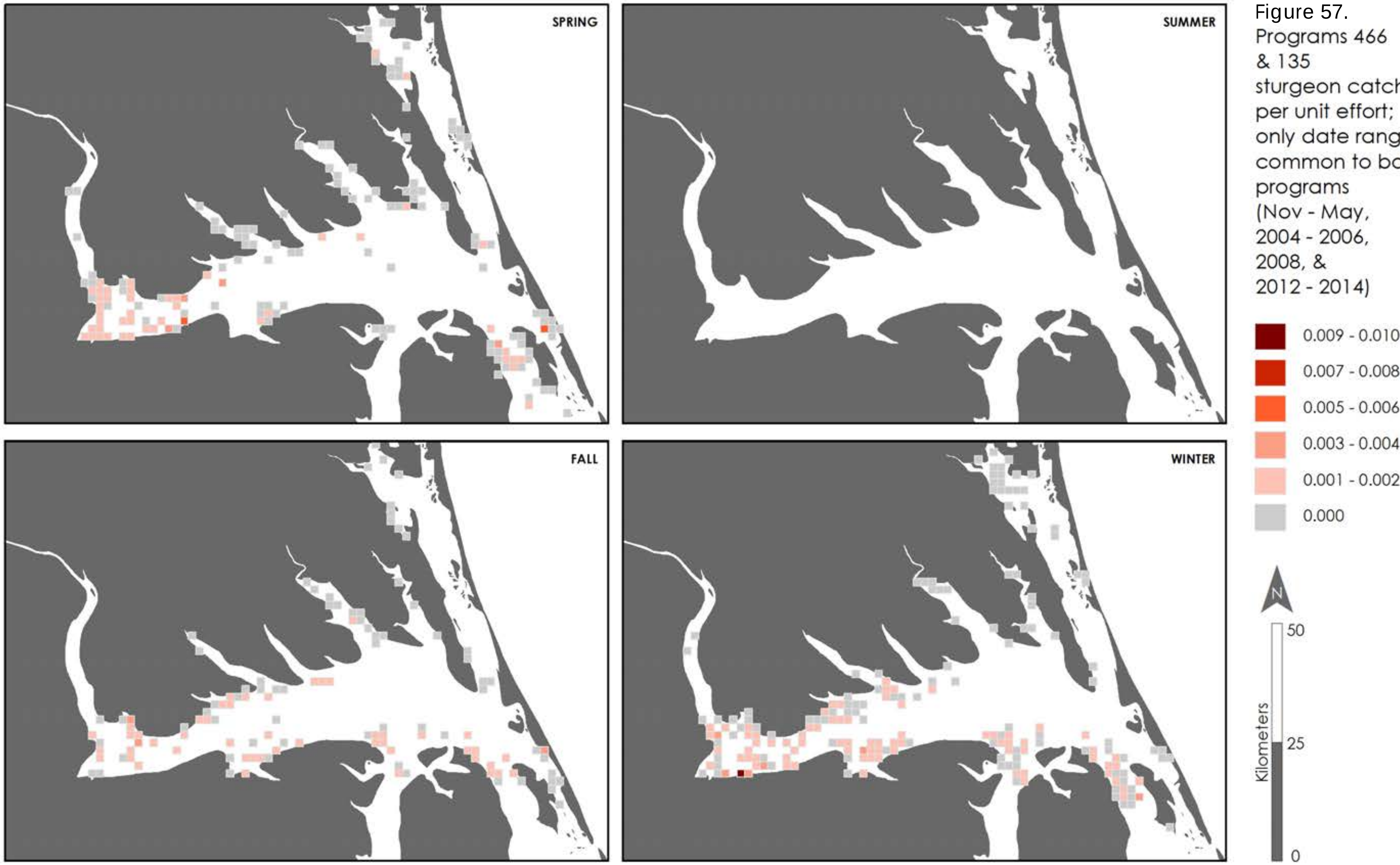


Figure 57. Programs 466 & 135 sturgeon catch per unit effort; only date ranges common to both programs (Nov - May, 2004 - 2006, 2008, & 2012 - 2014)

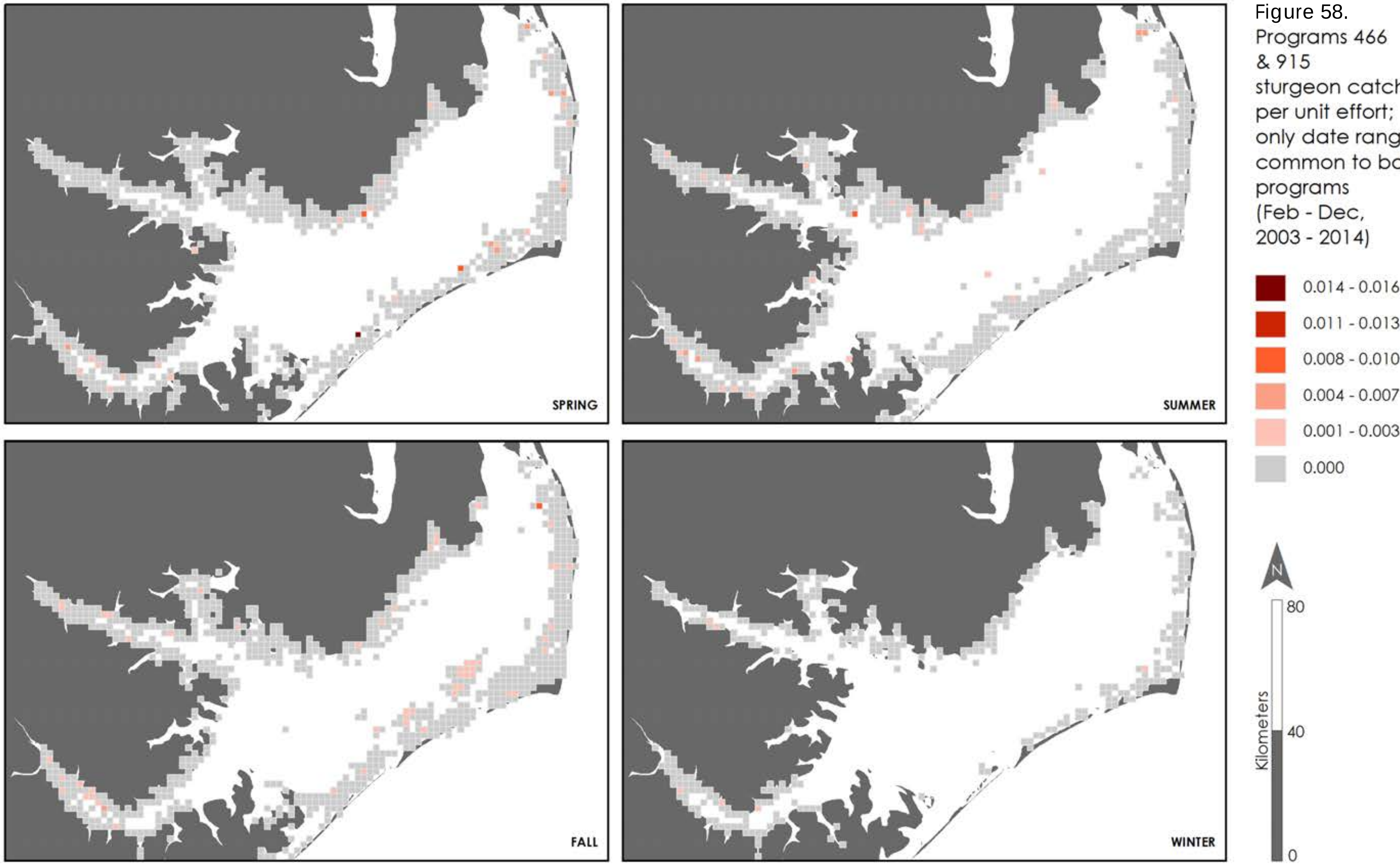


Figure 58. Programs 466 & 915 sturgeon catch per unit effort; only date ranges common to both programs (Feb - Dec, 2003 - 2014)

PRESENCE/ABSENCE MERGE, ONLY COMMON DATE RANGES - SEASONAL

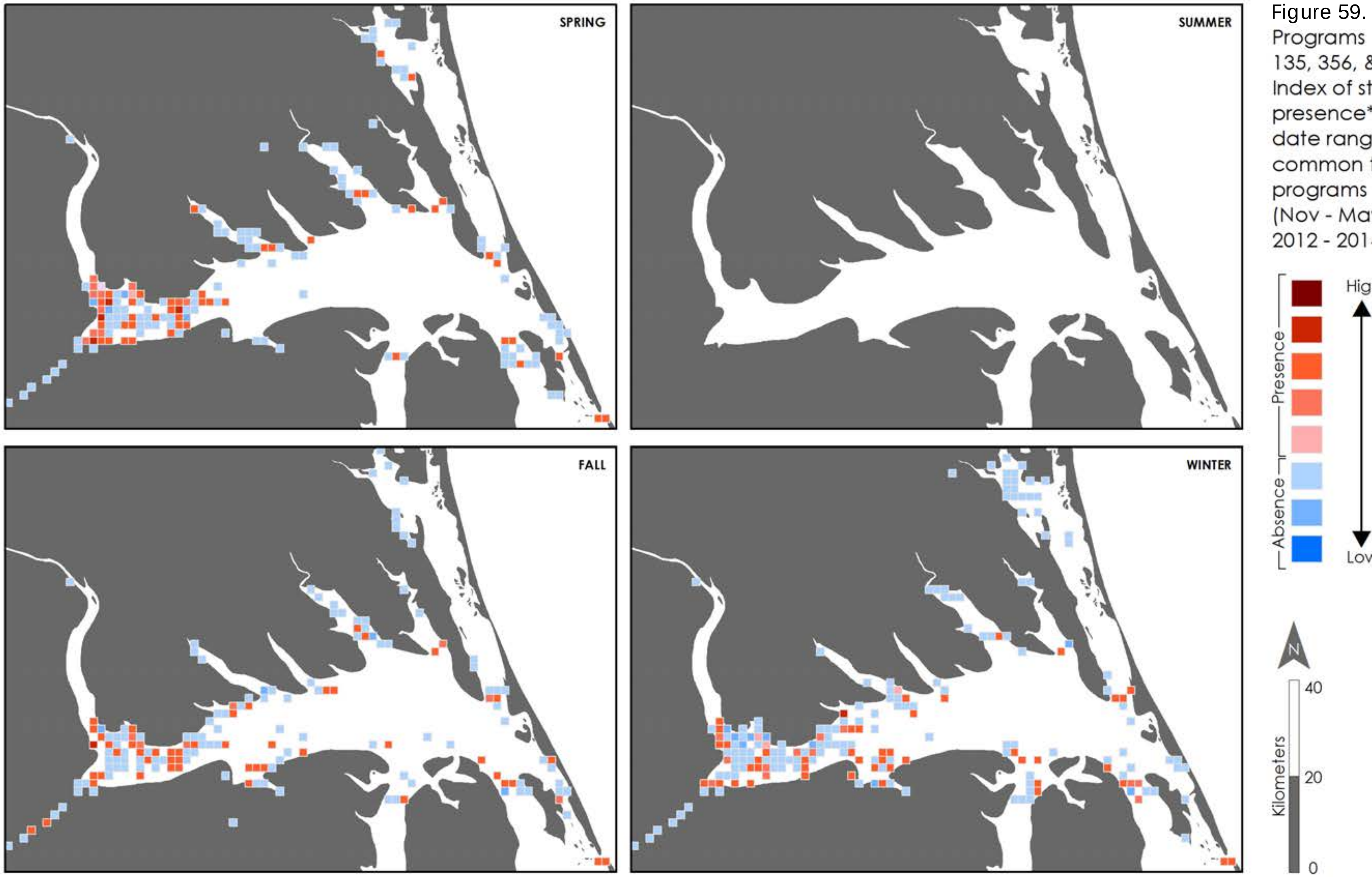


Figure 59. Programs 135, 356, & 466 Index of sturgeon presence*; only date ranges common to all programs (Nov - May, 2012 - 2014)

*This index takes into account whether or not a sturgeon was recorded in a given grid cell for each dataset, as well as the number of datasets for which sampling occured in that grid cell during the given time period. The lowest index value is given to grid cells where an absence was recorded in all three datasets, and the highest index value is given to grid cells where a presence was recorded in all three datasets. See methods section for a more detailed explanation.

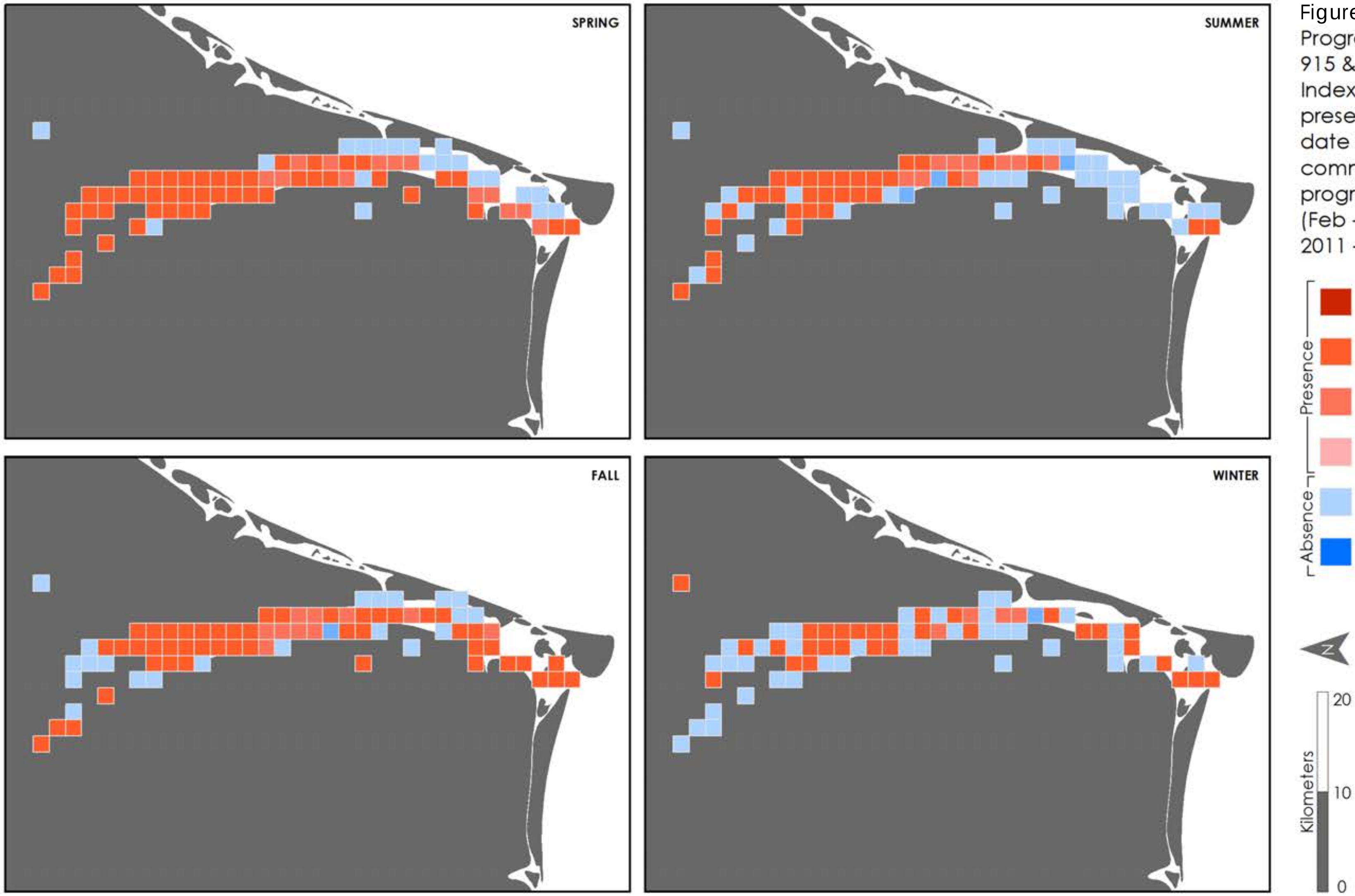


Figure 60. Programs 915 & 356 Index of sturgeon presence*; only date ranges common to both programs (Feb - Dec, 2011 - 2014)

*This index takes into account whether or not a sturgeon was recorded in a given grid cell for each dataset, as well as the number of datasets for which sampling occured in that grid cell during the given time period. The lowest index value is given to grid cells where an absence was recorded in all three datasets, and the highest index value is given to grid cells where a presence was recorded in all three datasets. See methods section for a more detailed explanation.

CATCH PER UNIT EFFORT MERGE - MONTHLY

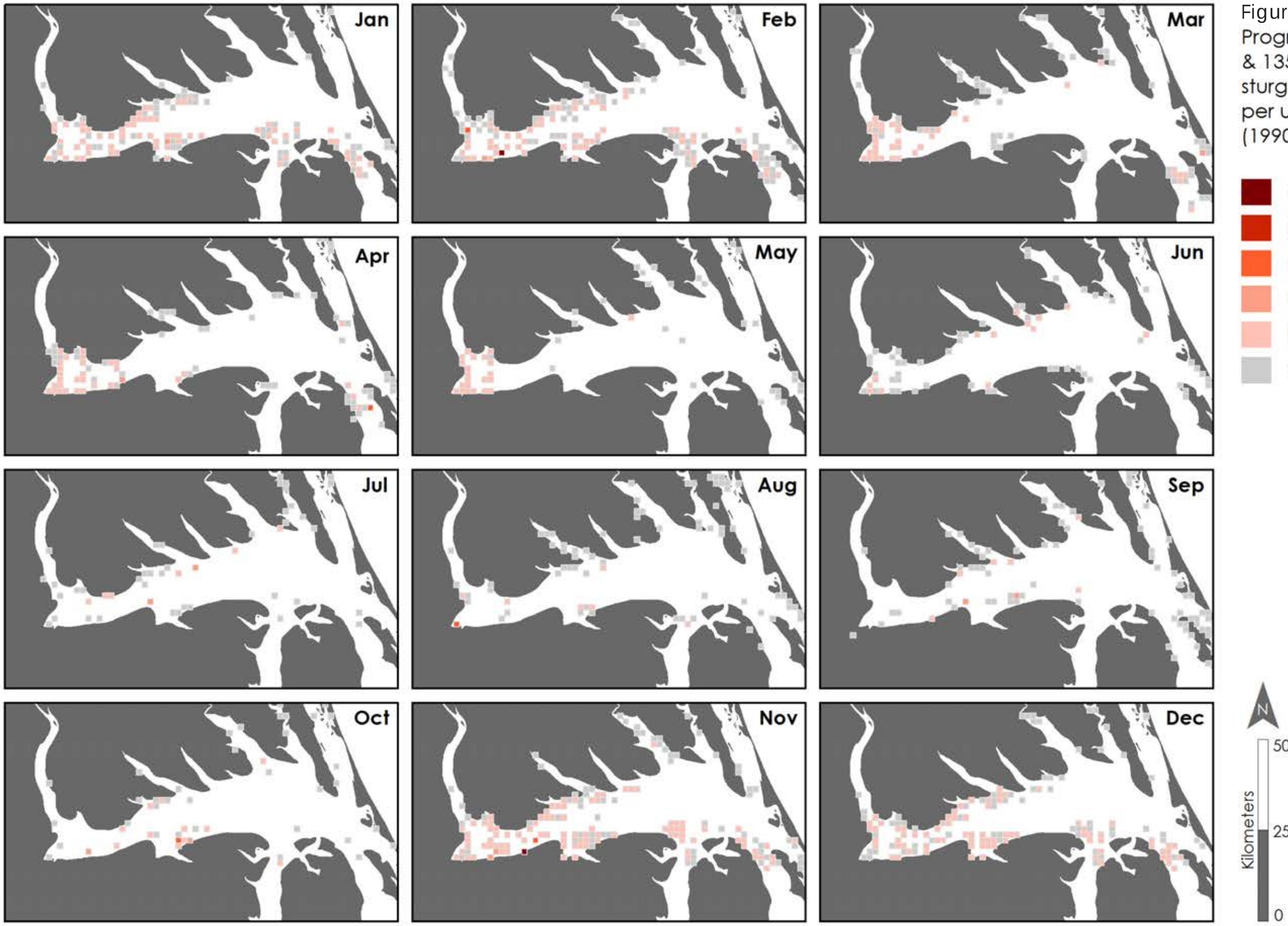


Figure 61. Programs 466 & 135 sturgeon catch per unit effort (1990 - 2015)

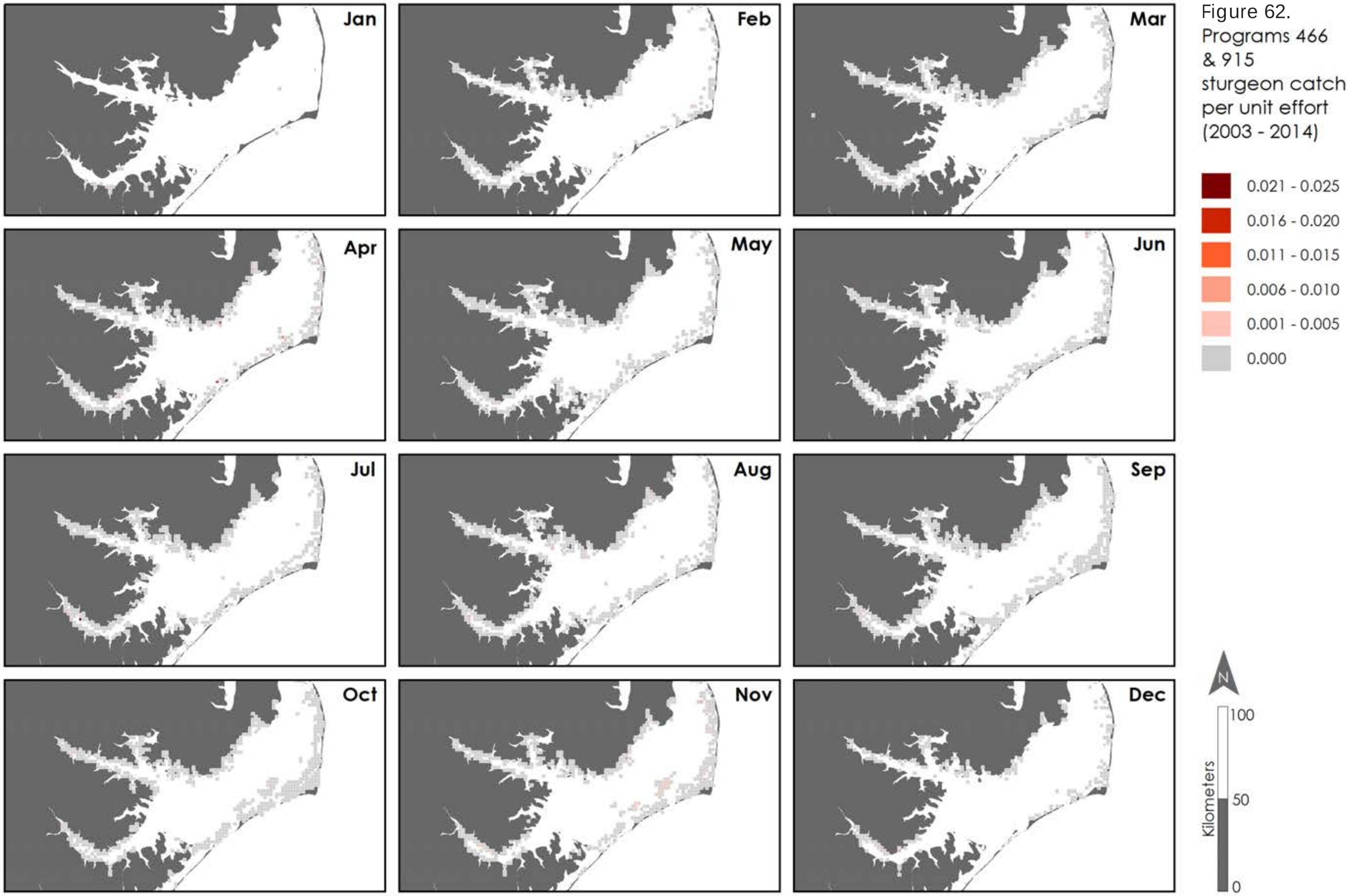
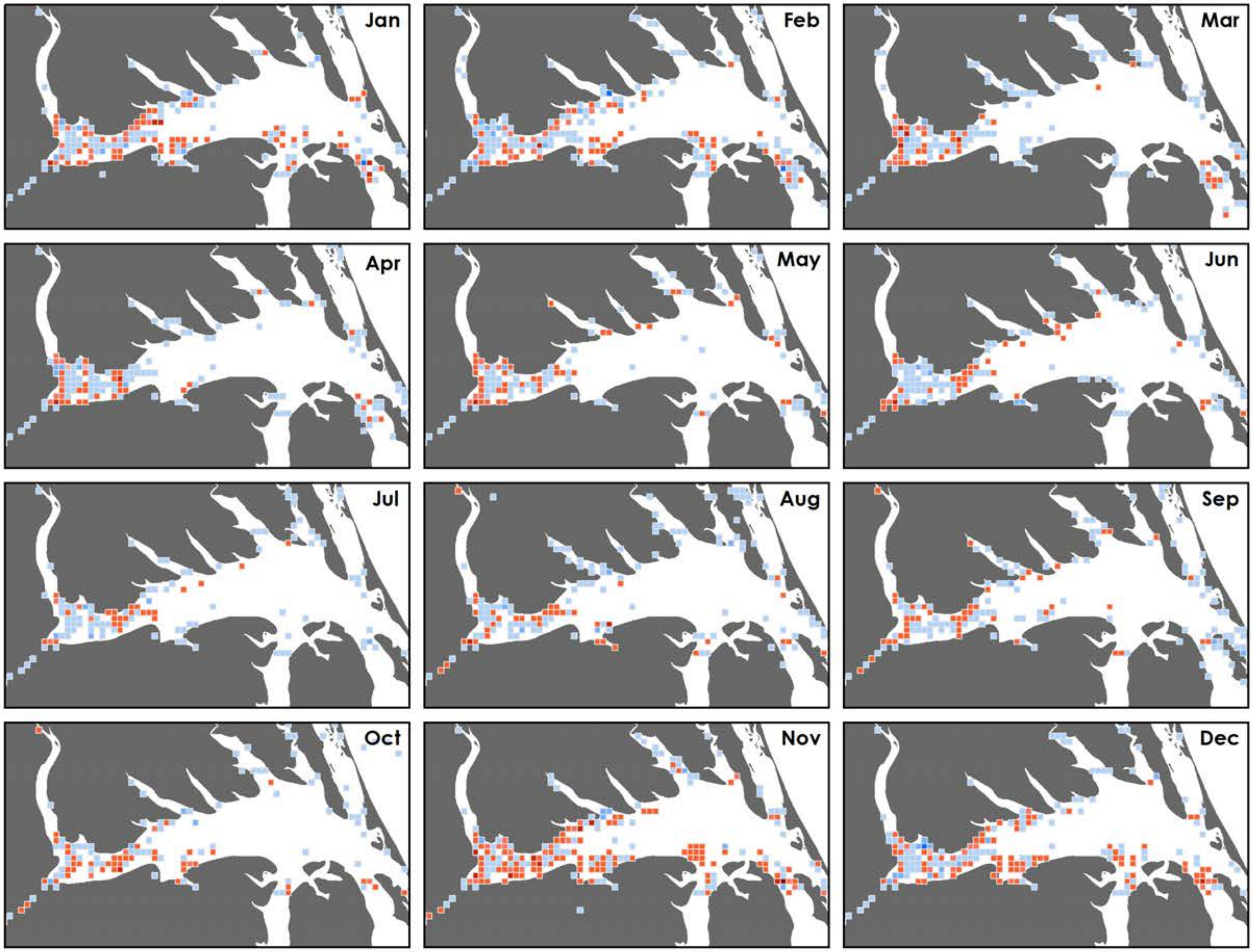


Figure 62. Programs 466 & 915 sturgeon catch per unit effort (2003 - 2014)

Figure 63.
Programs
135, 356, & 466
Index of sturgeon
presence*
(1990 - 2015)



*This index takes into account whether or not a sturgeon was recorded in a given grid cell for each dataset, as well as the number of datasets for which sampling occured in that grid cell during the given time period. The lowest index value is given to grid cells where an absence was recorded in all three datasets, and the highest index value is given to grid cells where a presence was recorded in all three datasets. See methods section for a more detailed explanation.

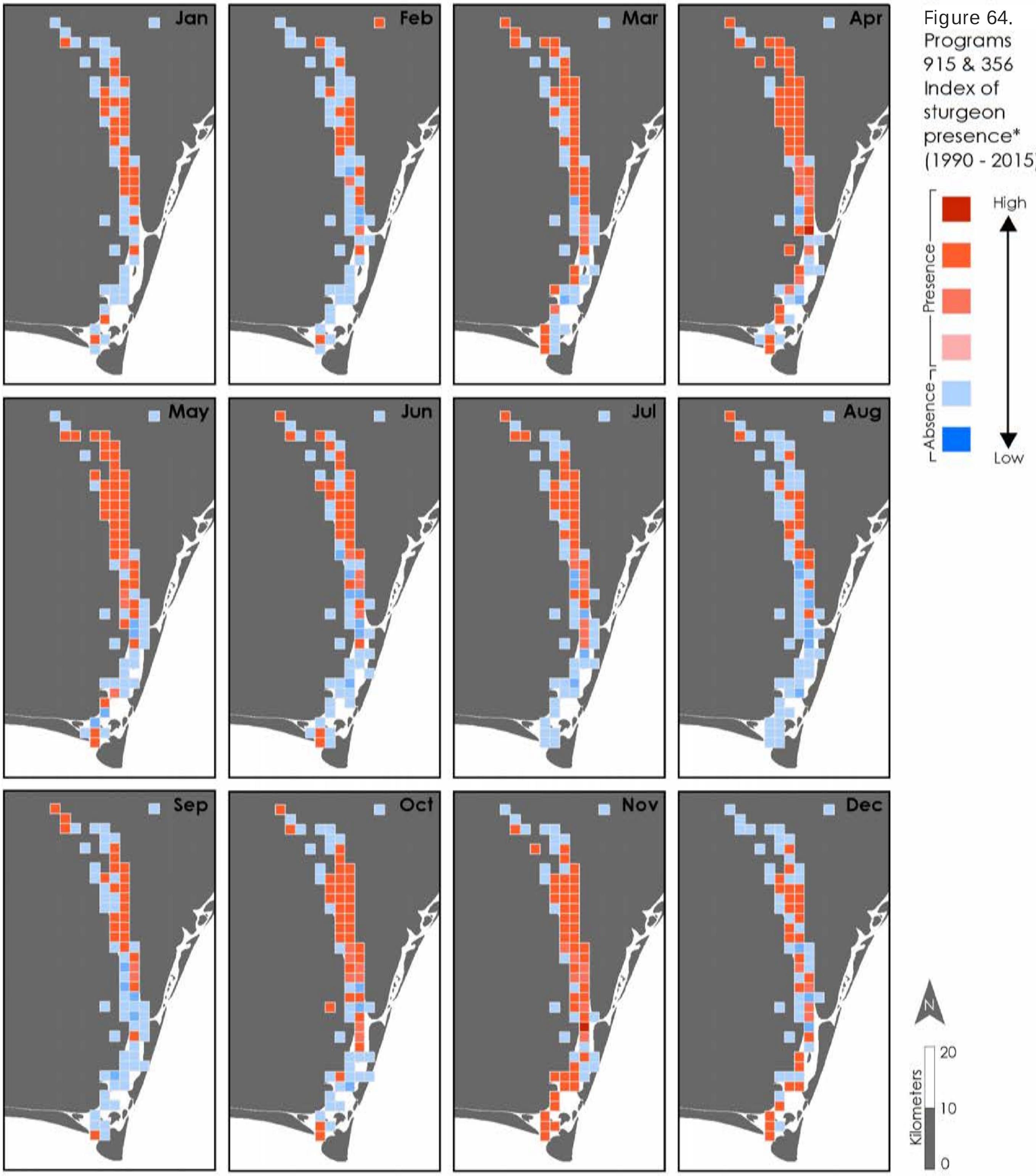


Figure 64. Programs 915 & 356 Index of sturgeon presence* (1990 - 2015)

*This index takes into account whether or not a sturgeon was recorded in a given grid cell for each dataset, as well as the number of datasets for which sampling occured in that grid cell during the given time period. The lowest index value is given to grid cells where an absence was recorded in all three datasets, and the highest index value is givento grid cells where a presence was recorded in all three datasets. See methods section for a more detailed explanation.

CATCH PER UNIT EFFORT MERGE, ONLY COMMON DATE RANGES - MONTHLY

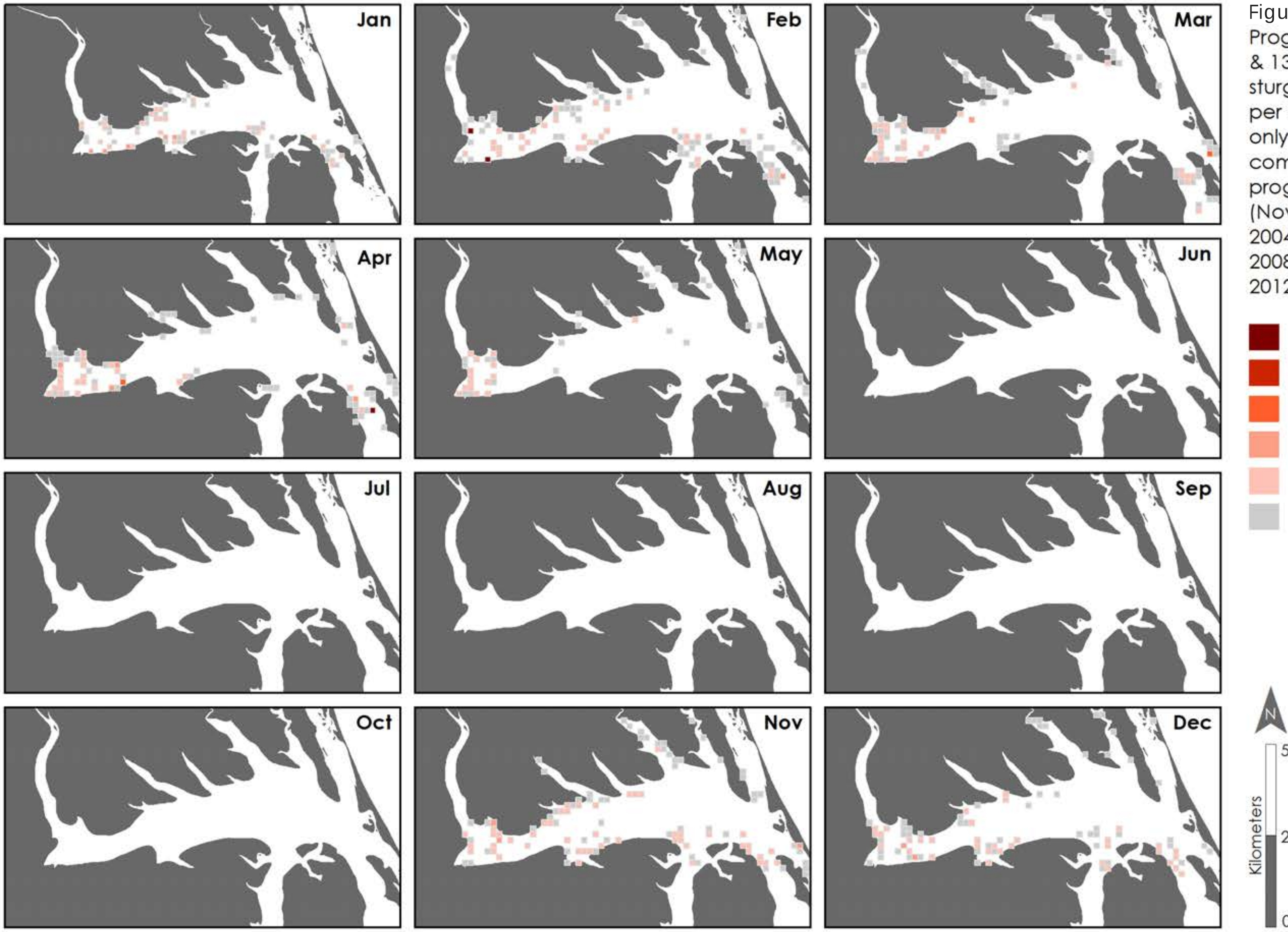


Figure 65. Programs 466 & 135 sturgeon catch per unit effort; only date ranges common to both programs (Nov - May, 2004 - 2006, 2008, & 2012 - 2014)

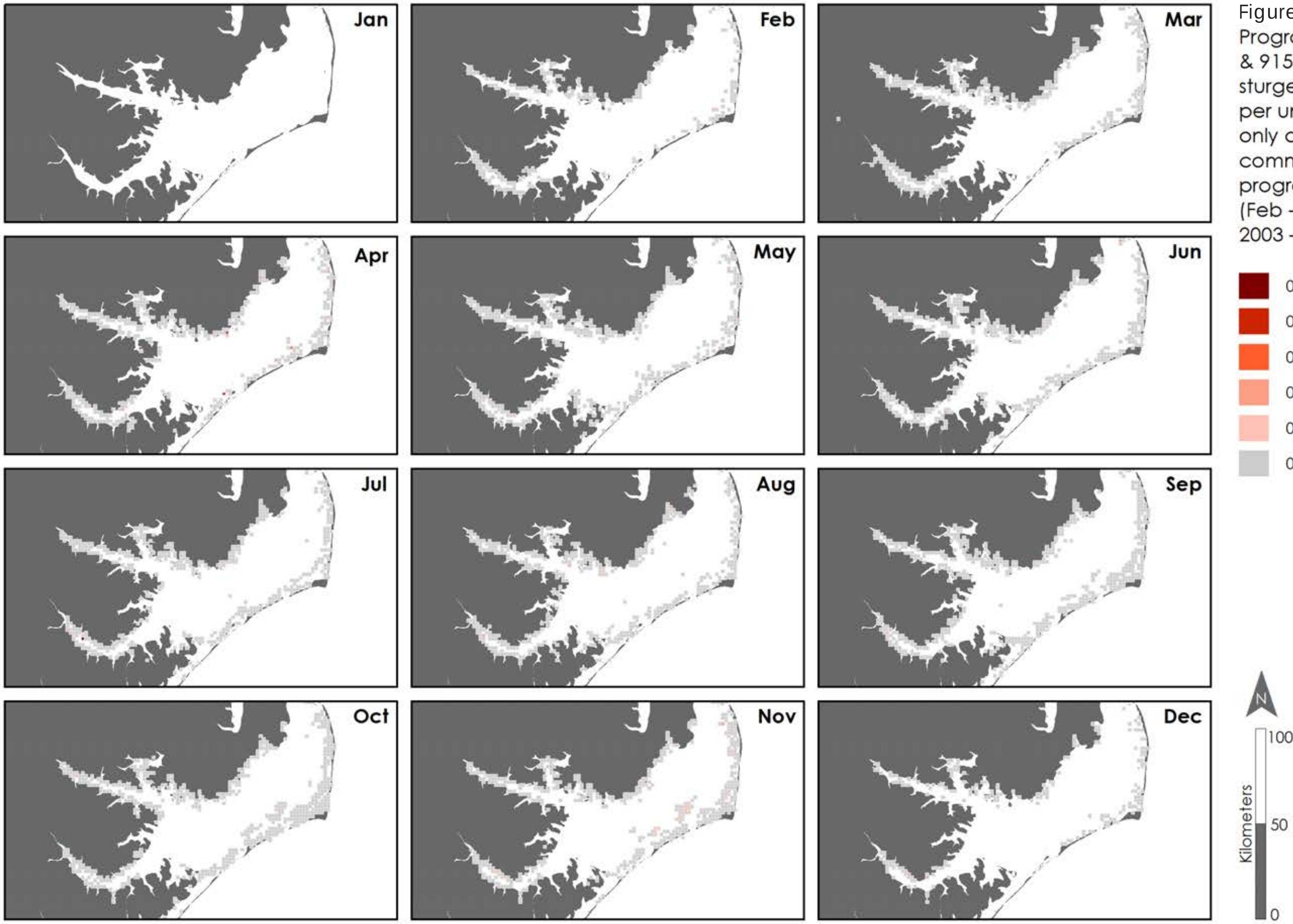


Figure 66. Programs 466 & 915 sturgeon catch per unit effort; only date ranges common to both programs (Feb - Dec, 2003 - 2014)

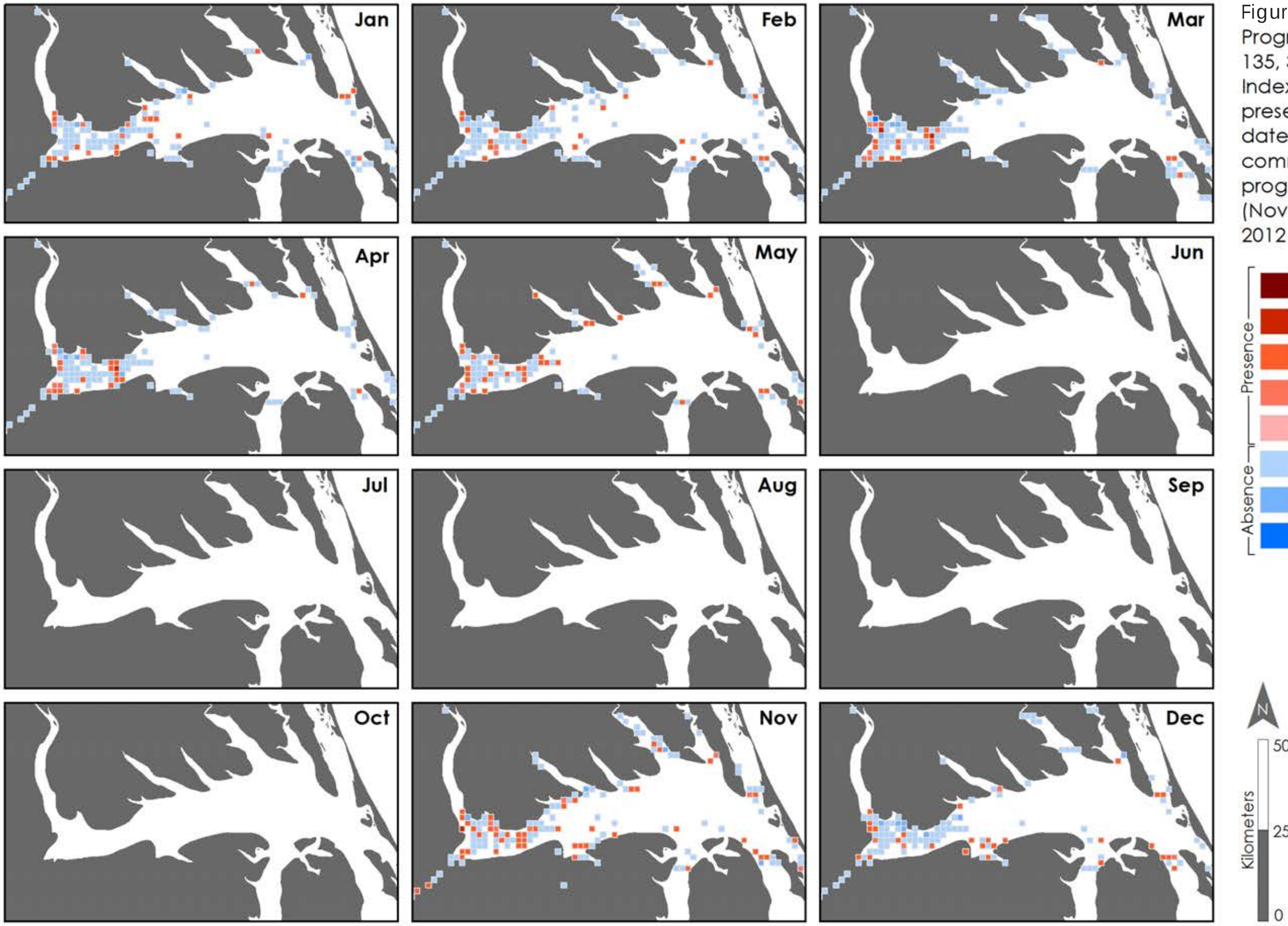


Figure 67. Programs 135, 356, & 466 Index of sturgeon presence*; only date ranges common to all programs (Nov - May, 2012 - 2014)

*This index takes into account whether or not a sturgeon was recorded in a given grid cell for each dataset, as well as the number of datasets for which sampling occured in that grid cell during the given time period. The lowest index value is given to grid cells where an absence was recorded in all three datasets, and the highest index value is given to grid cells where a presence was recorded in all three datasets. See methods section for a more detailed explanation.

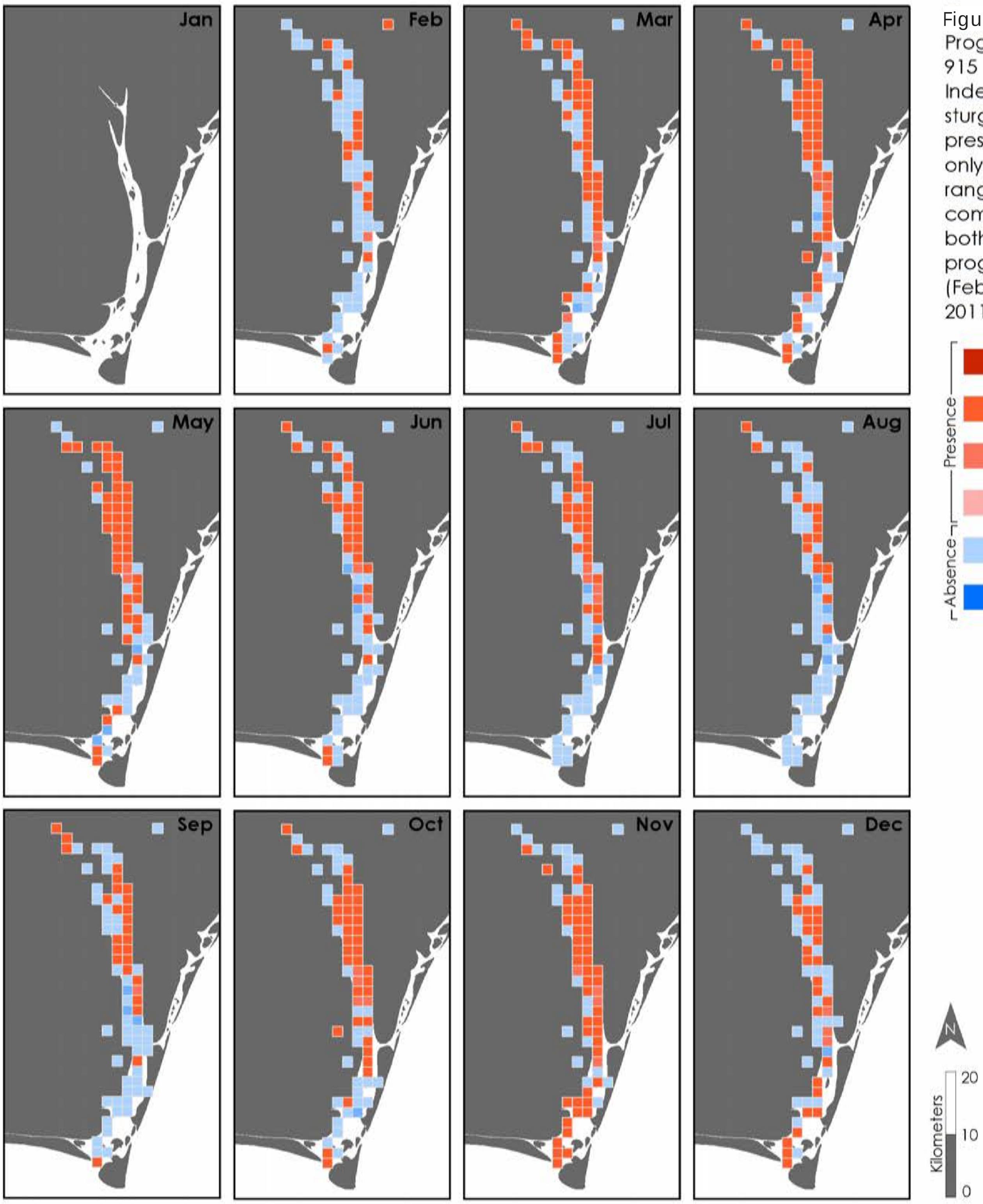


Figure 68. Programs 915 & 356 Index of sturgeon presence*; only date ranges common to both programs (Feb - Dec, 2011 - 2014)

*This index takes into account whether or not a sturgeon was recorded in a given grid cell for each dataset, as well as the number of datasets for which sampling occured in that grid cell during the given time period. The lowest index value is given to grid cells where an absence was recorded in all three datasets, and the highest index value is givento grid cells where a presence was recorded in all three datasets. See methods section for a more detailed explanation.

STURGEON BYCATCH PER UNIT EFFORT

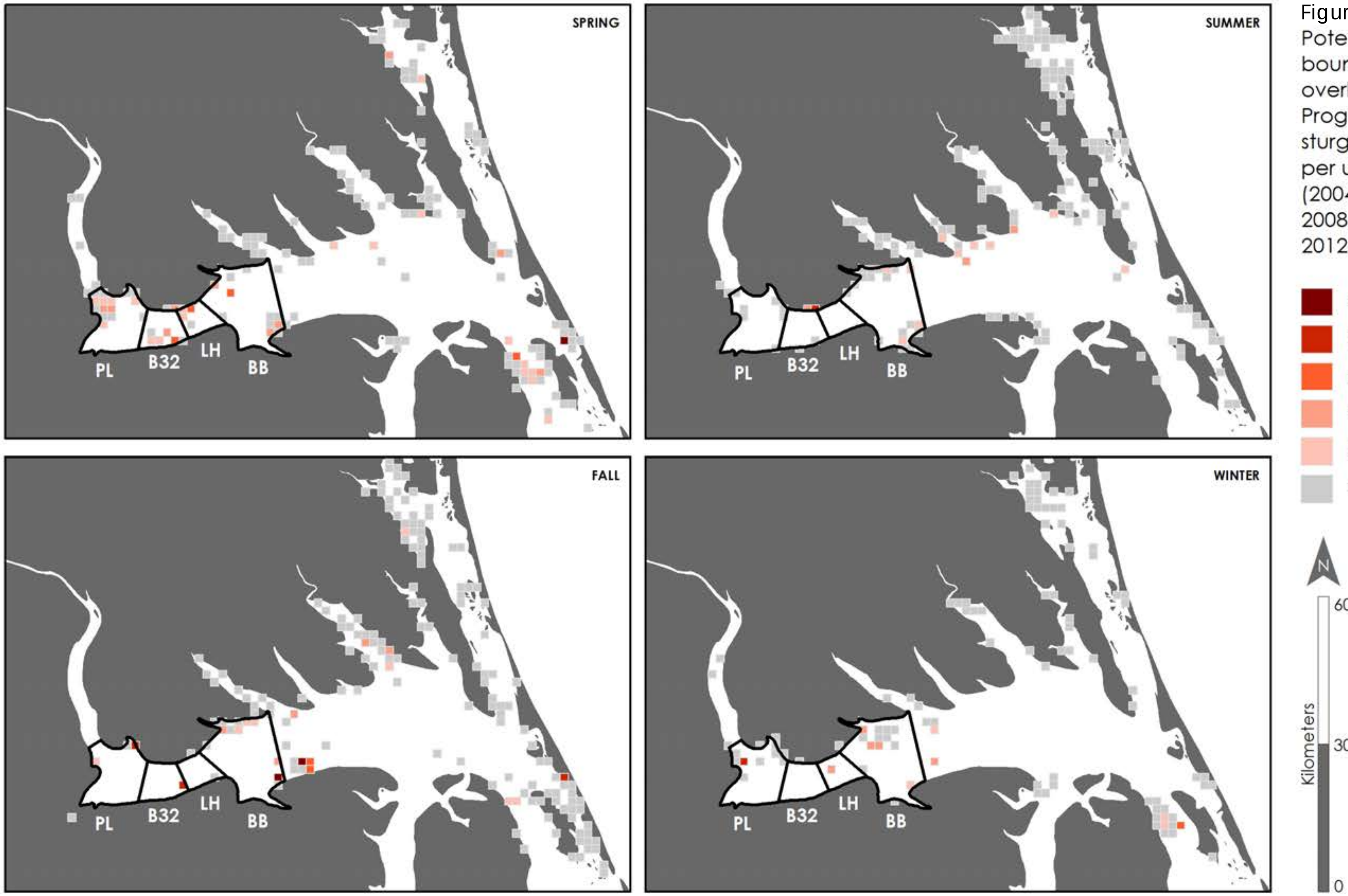


Figure 69. Potential closure boundaries overlaid on Program 466 sturgeon catch per unit effort (2004 - 2006, 2008, & 2012-2014)*

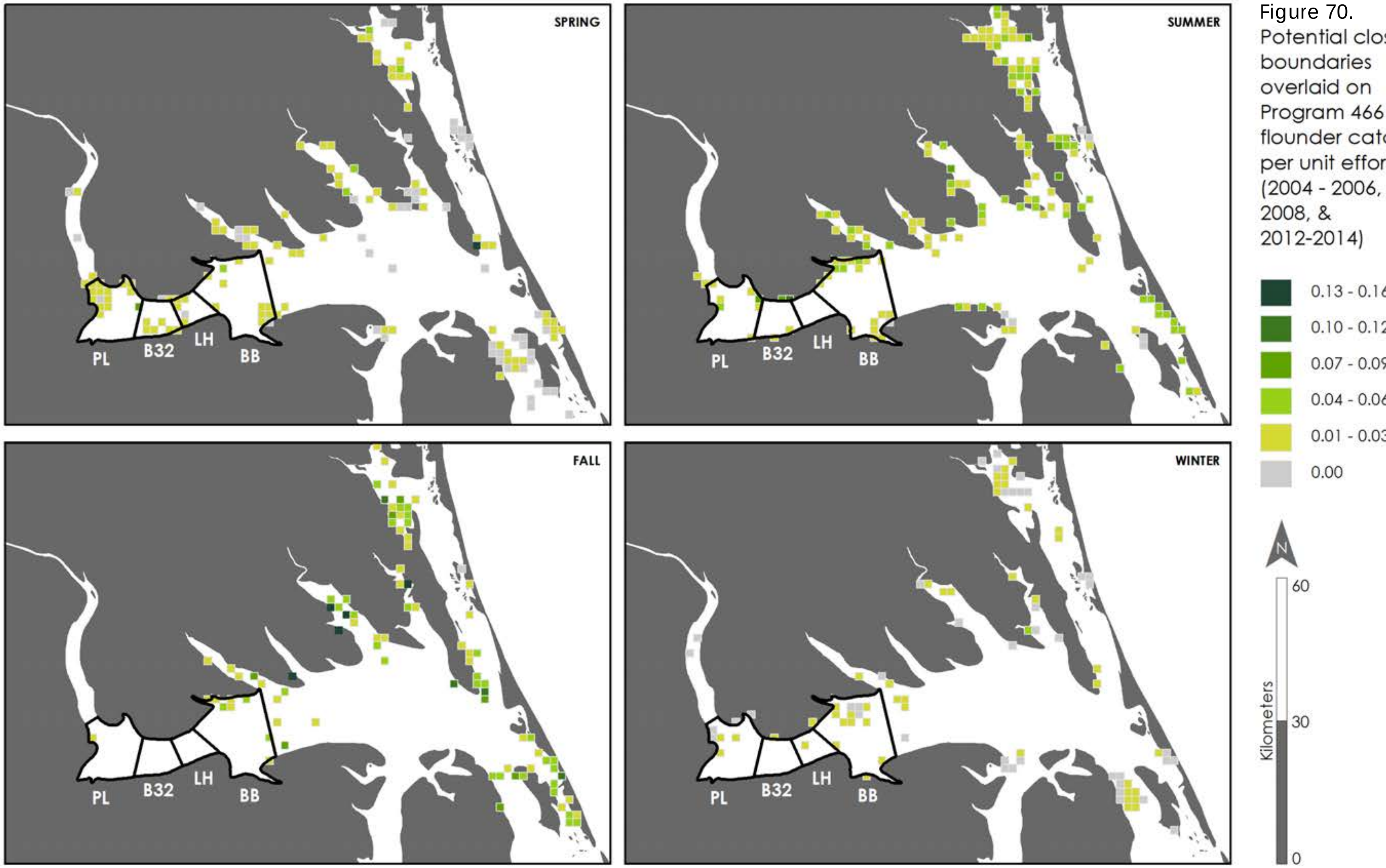


Figure 70. Potential closure boundaries overlaid on Program 466 flounder catch per unit effort (2004 - 2006, 2008, & 2012-2014)

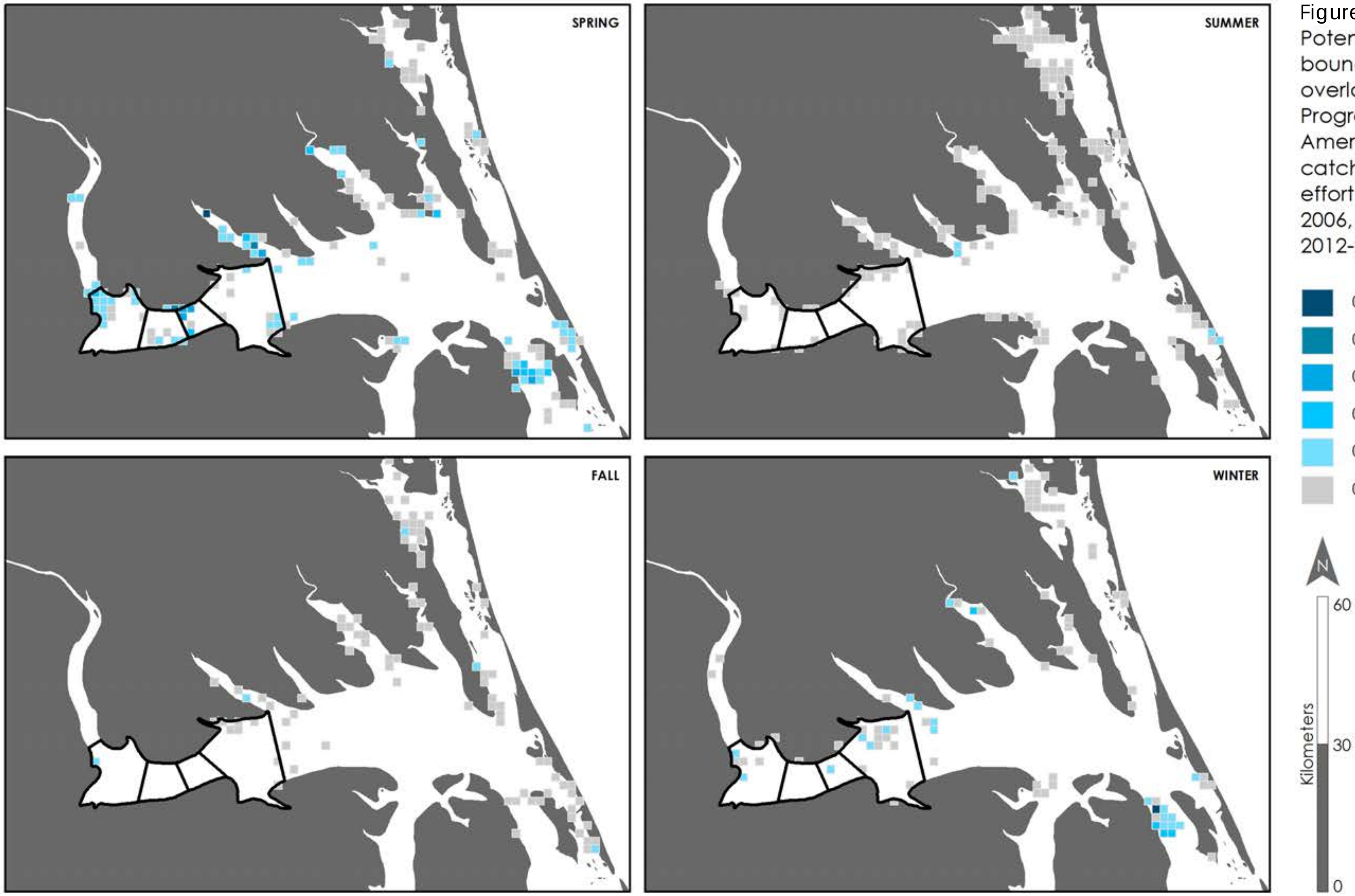


Figure 71. Potential closure boundaries overlaid on Program 466 American shad catch per unit effort (2004 - 2006, 2008, & 2012-2014)*

Table 1. Predicted number of sturgeon caught in Albemarle Sound during spring from 2004 - 2006, 2008, & 2012 - 2014 under different effort redistribution & closure scenarios.

	Closed Areas	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
		No Closure (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed based on previous distribution of effort	Effort redistributed based on distance to closed area boundary
SPRING - STURGEON	PL	86	77	88	87	97
	B32	86	68	74	73	93
	LH	86	71	74	74	78
	BB	86	74	81	80	84
	PL_B32	86	59	76	72	131
	B32_LH	86	53	60	60	62
	LH_BB	86	59	67	67	66
	PL_B32_LH	86	44	57	57	58
	B32_LH_BB	86	41	52	50	45
	PL_B32_LH_BB	86	32	48	46	32

Table 2. Percent change in the predicted number of sturgeon caught in Albemarle Sound during spring from 2004 - 2006, 2008, & 2012 - 2014 under different effort redistribution & closure scenarios.

SPRING - STURGEON		Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	Closed Areas	**No Closure (current scenario)**	**Effort not redistributed**	**Effort redistributed evenly**	**Effort redistributed based on previous distribution of effort**	**Effort redistributed based on distance to closed area boundary**
	PL	0%	-10.5%	2.3%	1.2%	12.8%
	B32	0%	-20.9%	-14.0%	-15.1%	8.1%
	LH	0%	-17.4%	-14.0%	-14.0%	-9.3%
	BB	0%	-14.0%	-5.8%	-7.0%	-2.3%
	PL_B32	0%	-31.4%	-11.6%	-16.3%	52.3%
	B32_LH	0%	-38.4%	-30.2%	-30.2%	-27.9%
	LH_BB	0%	-31.4%	-22.1%	-22.1%	-23.3%
	PL_B32_LH	0%	-48.8%	-33.7%	-33.7%	-32.6%
	B32_LH_BB	0%	-52.3%	-39.5%	-41.9%	-47.7%
	PL_B32_LH_BB	0%	-62.8%	-44.2%	-46.5%	-62.8%

Table 3. Analysis of the efficiency of different closure scenarios under effort redistribution scenarios #3 & #4 during spring between 2004 - 2006, 2008, & 2012 - 2014 in Albemarle Sound.

	Closed Areas	Total area closed (km^2)	Effort displaced (yard-days)	Reduction in the number of sturgeon takes		Ratio of sturgeon saved to area closed		Ratio of sturgeon saved to effort displaced	
				Scenario 3	Scenario 4	Scenario 3	Scenario 4	Scenario 3	Scenario 4
SPRING - STURGEON	**PL**	121	34113	-1	-11	-0.0082	-0.0906	0.0000	-0.0003
	B32	59	20580	13	-7	0.2201	-0.1185	0.0006	-0.0003
	LH	41	13890	12	8	0.2895	0.1930	0.0009	0.0006
	BB	199	20980	6	2	0.0301	0.0100	0.0003	0.0001
	PL_B32	181	54693	14	-45	0.0775	-0.2493	0.0003	-0.0008
	B32_LH	101	34470	26	24	0.2587	0.2388	0.0008	0.0007
	LH_BB	241	34870	19	20	0.0790	0.0831	0.0005	0.0006
	PL_B32_LH	222	68583	29	28	0.1306	0.1261	0.0004	0.0004
	B32_LH_BB	300	55450	36	41	0.1201	0.1368	0.0006	0.0007
	PL_B32_LH_BB	421	89563	40	54	0.0950	0.1282	0.0004	0.0006

Table 4. Predicted number of flounder caught in Albemarle Sound during spring from 2004 - 2006, 2008, & 2012 - 2014 under different effort redistribution & closure scenarios.

SPRING - FLOUNDER	Closed Areas	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
		No Closure (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed based on previous distribution of effort	Effort redistributed based on distance to closed area boundary
	PL	1701	1456	1616	1644	1580
	B32	1701	1568	1661	1684	1656
	LH	1701	1683	1749	1765	1759
	BB	1701	1484	1577	1596	1544
	PL_B32	1701	1323	1578	1619	1430
	B32_LH	1701	1550	1714	1752	1977
	LH_BB	1701	1466	1629	1660	1601
	PL_B32_LH	1701	1305	1643	1694	1675
	B32_LH_BB	1701	1333	1590	1637	1712
	PL_B32_LH_BB	1701	1088	1517	1554	1372

Table 5. Percent change in the predicted number of flounder caught in Albemarle Sound during spring from 2004 - 2006, 2008, & 2012 - 2014 under different effort redistribution & closure scenarios.

SPRING - FLOUNDER	Closed Areas	Scenario 0 No Closure (current scenario)	Scenario 1 Effort not redistributed	Scenario 2 Effort redistributed evenly	Scenario 3 Effort redistributed based on previous distribution of effort	Scenario 4 Effort redistributed based on distance to closed area boundary
	PL	0%	-14.4%	-5.0%	-3.4%	-7.1%
	B32	0%	-7.8%	-2.4%	-1.0%	-2.6%
	LH	0%	-1.1%	2.8%	3.8%	3.4%
	BB	0%	-12.8%	-7.3%	-6.2%	-9.2%
	PL_B32	0%	-22.2%	-7.2%	-4.8%	-15.9%
	B32_LH	0%	-8.9%	0.8%	3.0%	16.2%
	LH_BB	0%	-13.8%	-4.2%	-2.4%	-5.9%
	PL_B32_LH	0%	-23.3%	-3.4%	-0.4%	-1.5%
	B32_LH_BB	0%	-21.6%	-6.5%	-3.8%	0.6%
	PL_B32_LH_BB	0%	-36.0%	-10.8%	-8.6%	-19.3%

Table 6. Predicted number of American shad caught in Albemarle Sound during spring from 2004 - 2006, 2008, & 2012 - 2014 under different effort redistribution & closure scenarios.

SPRING - AMERICAN SHAD	Closed Areas	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
		No Closure (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed based on previous distribution of effort	Effort redistributed based on distance to closed area boundary
	PL	3063	2811	3343	3173	3368
	B32	3063	2949	3260	3167	4092
	LH	3063	2454	2608	2574	2664
	BB	3063	2951	3275	3174	3667
	PL_B32	3063	2697	3559	3301	6043
	B32_LH	3063	2340	2722	2645	2608
	LH_BB	3063	2342	2737	2651	3039
	PL_B32_LH	3063	2088	2851	2710	2494
	B32_LH_BB	3063	2228	2855	2736	3188
	PL_B32_LH_BB	3063	1976	2996	2822	3666

Table 7. Percent change in the predicted number of American shad caught in Albemarle Sound during spring from 2004 - 2006, 2008, & 2012 - 2014 under different effort redistribution & closure scenarios.

SPRING - AMERICAN SHAD		Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	Closed Areas	**No Closure (current scenario)**	**Effort not redistributed**	**Effort redistributed evenly**	**Effort redistributed based on previous distribution of effort**	**Effort redistributed based on distance to closed area boundary**
	PL	0%	-8.2%	9.1%	3.6%	10.0%
	B32	0%	-3.7%	6.4%	3.4%	33.6%
	LH	0%	-19.9%	-14.9%	-16.0%	-13.0%
	BB	0%	-3.7%	6.9%	3.6%	19.7%
	PL_B32	0%	-11.9%	16.2%	7.8%	97.3%
	B32_LH	0%	-23.6%	-11.1%	-13.6%	-14.9%
	LH_BB	0%	-23.5%	-10.6%	-13.5%	-0.8%
	PL_B32_LH	0%	-31.8%	-6.9%	-11.5%	-18.6%
	B32_LH_BB	0%	-27.3%	-6.8%	-10.7%	4.1%
	PL_B32_LH_BB	0%	-35.5%	-2.2%	-7.9%	19.7%

Table 8. Predicted number of sturgeon caught in Albemarle Sound during summer from 2004 - 2006, 2008, & 2012 - 2014 under different effort redistribution & closure scenarios.

SUMMER - STURGEON	Closed Areas	Scenario 0 No Closure (current scenario)	Scenario 1 Effort not redistributed	Scenario 2 Effort redistributed evenly	Scenario 3 Effort redistributed based on previous distribution of effort	Scenario 4 Effort redistributed based on distance to closed area boundary
	PL	24	24	25	25	28
	B32	24	21	21	21	21
	LH	24	24	24	24	24
	BB	24	16	19	18	22
	PL_B32	24	21	21	22	21
	B32_LH	24	21	21	21	21
	LH_BB	24	16	19	18	45
	PL_B32_LH	24	21	21	22	22
	B32_LH_BB	24	13	14	15	13
	PL_B32_LH_BB	24	13	14	16	14

Table 9. Percent change in the predicted number of sturgeon caught in Albemarle Sound during summer from 2004 - 2006, 2008, & 2012 - 2014 under different effort redistribution & closure scenarios.

SUMMER - STURGEON	Closed Areas	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
		No Closure (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed based on previous distribution of effort	Effort redistributed based on distance to closed area boundary
	PL	0%	0.0%	4.2%	4.2%	16.7%
	B32	0%	-12.5%	-12.5%	-12.5%	-12.5%
	LH	0%	0.0%	0.0%	0.0%	0.0%
	BB	0%	-33.3%	-20.8%	-25.0%	-8.3%
	PL_B32	0%	-12.5%	-12.5%	-8.3%	-12.5%
	B32_LH	0%	-12.5%	-12.5%	-12.5%	-12.5%
	LH_BB	0%	-33.3%	-20.8%	-25.0%	87.5%
	PL_B32_LH	0%	-12.5%	-12.5%	-8.3%	-8.3%
	B32_LH_BB	0%	-45.8%	-41.7%	-37.5%	-45.8%
	PL_B32_LH_BB	0%	-45.8%	-41.7%	-33.3%	-41.7%

Table 10. Analysis of the efficiency of different closure scenarios under effort redistribution scenarios #3 & #4 during summer between 2004 - 2006, 2008, & 2012 - 2014 in Albemarle Sound.

SUMMER - STURGEON	Closed Areas	Total area closed (km^2)	Effort displaced (yard-days)	Reduction in the number of sturgeon takes		Ratio of sturgeon saved to area closed		Ratio of sturgeon saved to effort displaced	
				Scenario 3	Scenario 4	Scenario 3	Scenario 4	Scenario 3	Scenario 4
	PL	121	9238	-1	-4	-0.0082	-0.0329	-0.0001	-0.0004
	B32	59	2820	3	3	0.0508	0.0508	0.0011	0.0011
	LH	41	0	0	0	0.0000	0.0000	NA	NA
	BB	199	53133	6	2	0.0301	0.0100	0.0001	0.0000
	PL_B32	181	12058	2	3	0.0111	0.0166	0.0002	0.0002
	B32_LH	101	2820	3	3	0.0298	0.0298	0.0011	0.0011
	LH_BB	241	53133	6	-21	0.0249	-0.0873	0.0001	-0.0004
	PL_B32_LH	222	12058	2	2	0.0090	0.0090	0.0002	0.0002
	B32_LH_BB	300	55953	9	11	0.0300	0.0367	0.0002	0.0002
	PL_B32_LH_BB	421	65192	8	10	0.0190	0.0237	0.0001	0.0002

Table 11. Predicted number of flounder caught in Albemarle Sound during summer from 2004 - 2006, 2008, & 2012 - 2014 under different effort redistribution & closure scenarios.

SUMMER - FLOUNDER	Closed Areas	Scenario 0 No Closure (current scenario)	Scenario 1 Effort not redistributed	Scenario 2 Effort redistributed evenly	Scenario 3 Effort redistributed based on previous distribution of effort	Scenario 4 Effort redistributed based on distance to closed area boundary
	PL	10101	9913	10167	10151	10188
	B32	10101	9933	10008	10005	9988
	LH	10101	10101	10101	10101	10101
	BB	10101	8964	10453	10361	10979
	PL_B32	10101	9745	10069	10053	9948
	B32_LH	10101	9933	10008	10005	9988
	LH_BB	10101	8964	10453	10361	11508
	PL_B32_LH	10101	9745	10069	10053	9961
	B32_LH_BB	10101	8796	10322	10251	10444
	PL_B32_LH_BB	10101	8608	10400	10314	10659

Table 12. Percent change in the predicted number of flounder caught in Albemarle Sound during summer from 2004 - 2006, 2008, & 2012 - 2014 under different effort redistribution & closure scenarios.

SUMMER - FLOUNDER		Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	Closed Areas	**No Closure (current scenario)**	**Effort not redistributed**	**Effort redistributed evenly**	**Effort redistributed based on previous distribution of effort**	**Effort redistributed based on distance to closed area boundary**
	PL	0%	-1.9%	0.7%	0.5%	0.9%
	B32	0%	-1.7%	-0.9%	-1.0%	-1.1%
	LH	0%	0.0%	0.0%	0.0%	0.0%
	BB	0%	-11.3%	3.5%	2.6%	8.7%
	PL_B32	0%	-3.5%	-0.3%	-0.5%	-1.5%
	B32_LH	0%	-1.7%	-0.9%	-1.0%	-1.1%
	LH_BB	0%	-11.3%	3.5%	2.6%	13.9%
	PL_B32_LH	0%	-3.5%	-0.3%	-0.5%	-1.4%
	B32_LH_BB	0%	-12.9%	2.2%	1.5%	3.4%
	PL_B32_LH_BB	0%	-14.8%	3.0%	2.1%	5.5%

Table 13. Predicted number of sturgeon caught in Albemarle Sound during fall from 2004 - 2006, 2008, & 2012 - 2014 under different effort redistribution & closure scenarios.

FALL - STURGEON	Closed Areas	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
		No Closure (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed based on previous distribution of effort	Effort redistributed based on distance to closed area boundary
	PL	35	33	33	33	34
	B32	35	29	29	29	30
	LH	35	35	36	35	36
	BB	35	22	26	25	27
	PL_B32	35	27	28	27	28
	B32_LH	35	29	30	30	30
	LH_BB	35	22	26	25	35
	PL_B32_LH	35	27	28	28	28
	B32_LH_BB	35	16	20	19	25
	PL_B32_LH_BB	35	14	17	16	21

Table 14. Percent change in the predicted number of sturgeon caught in Albemarle Sound during fall from 2004 - 2006, 2008, & 2012 - 2014 under different effort redistribution & closure scenarios.

FALL - STURGEON	Closed Areas	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
		No Closure (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed based on previous distribution of effort	Effort redistributed based on distance to closed area boundary
	PL	0%	-5.7%	-5.7%	-5.7%	-2.9%
	B32	0%	-17.1%	-17.1%	-17.1%	-14.3%
	LH	0%	0.0%	2.9%	0.0%	2.9%
	BB	0%	-37.1%	-25.7%	-28.6%	-22.9%
	PL_B32	0%	-22.9%	-20.0%	-22.9%	-20.0%
	B32_LH	0%	-17.1%	-14.3%	-14.3%	-14.3%
	LH_BB	0%	-37.1%	-25.7%	-28.6%	0.0%
	PL_B32_LH	0%	-22.9%	-20.0%	-20.0%	-20.0%
	B32_LH_BB	0%	-54.3%	-42.9%	-45.7%	-28.6%
	PL_B32_LH_BB	0%	-60.0%	-51.4%	-54.3%	-40.0%

Table 15. Analysis of the efficiency of different closure scenarios under effort redistribution scenarios #3 & #4 during fall between 2004 - 2006, 2008, & 2012 - 2014 in Albemarle Sound.

	Closed Areas	Total area closed (km²)	Effort displaced (yard-days)	Reduction in the number of sturgeon takes		Ratio of sturgeon saved to area closed		Ratio of sturgeon saved to effort displaced	
				Scenario 3	Scenario 4	Scenario 3	Scenario 4	Scenario 3	Scenario 4
FALL - STURGEON	PL	121	2100	2	1	0.0165	0.0082	0.0010	0.0005
	B32	59	2002	6	5	0.1016	0.0847	0.0030	0.0025
	LH	41	3150	0	-1	0.0000	-0.0241	0.0000	-0.0003
	BB	199	27166	10	8	0.0502	0.0402	0.0004	0.0003
	PL_B32	181	4102	8	7	0.0443	0.0388	0.0020	0.0017
	B32_LH	101	5152	5	5	0.0497	0.0497	0.0010	0.0010
	LH_BB	241	30316	10	0	0.0416	0.0000	0.0003	0.0000
	PL_B32_LH	222	7252	7	7	0.0315	0.0315	0.0010	0.0010
	B32_LH_BB	300	32318	16	10	0.0534	0.0334	0.0005	0.0003
	PL_B32_LH_BB	421	34418	19	14	0.0451	0.0332	0.0006	0.0004

Table 16. Predicted number of flounder caught in Albemarle Sound during fall from 2004 - 2006, 2008, & 2012 - 2014 under different effort redistribution & closure scenarios.

FALL - FLOUNDER		Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	Closed Areas	**No Closure (current scenario)**	**Effort not redistributed**	**Effort redistributed evenly**	**Effort redistributed based on previous distribution of effort**	**Effort redistributed based on distance to closed area boundary**
	PL	7648	7640	7721	7710	7759
	B32	7648	7614	7690	7680	7691
	LH	7648	7468	7588	7571	7751
	BB	7648	6994	7997	7925	8117
	PL_B32	7648	7606	7765	7743	7822
	B32_LH	7648	7434	7630	7603	7904
	LH_BB	7648	6814	7931	7842	7988
	PL_B32_LH	7648	7426	7707	7666	8133
	B32_LH_BB	7648	6780	7973	7881	8035
	PL_B32_LH_BB	7648	6772	8069	7956	8191

Table 17. Percent change in the predicted number of flounder caught in Albemarle Sound during fall from 2004 - 2006, 2008, & 2012 - 2014 under different effort redistribution & closure scenarios.

FALL - FLOUNDER	Closed Areas	Scenario 0 No Closure (current scenario)	Scenario 1 Effort not redistributed	Scenario 2 Effort redistributed evenly	Scenario 3 Effort redistributed based on previous distribution of effort	Scenario 4 Effort redistributed based on distance to closed area boundary
	PL	0%	-0.1%	1.0%	0.8%	1.5%
	B32	0%	-0.4%	0.5%	0.4%	0.6%
	LH	0%	-2.4%	-0.8%	-1.0%	1.3%
	BB	0%	-8.6%	4.6%	3.6%	6.1%
	PL_B32	0%	-0.5%	1.5%	1.2%	2.3%
	B32_LH	0%	-2.8%	-0.2%	-0.6%	3.3%
	LH_BB	0%	-10.9%	3.7%	2.5%	4.4%
	PL_B32_LH	0%	-2.9%	0.8%	0.2%	6.3%
	B32_LH_BB	0%	-11.3%	4.2%	3.0%	5.1%
	PL_B32_LH_BB	0%	-11.5%	5.5%	4.0%	7.1%

Table 18. Predicted number of sturgeon caught in Albemarle Sound during winter from 2004 - 2006, 2008, & 2012 - 2014 under different effort redistribution & closure scenarios.

WINTER - STURGEON		Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	Closed Areas	No Closure (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed based on previous distribution of effort	Effort redistributed based on distance to closed area boundary
	PL	21	18	19	19	20
	B32	21	21	21	21	21
	LH	21	20	20	20	20
	BB	21	15	17	17	20
	PL_B32	21	18	19	19	26
	B32_LH	21	20	20	20	20
	LH_BB	21	14	16	16	19
	PL_B32_LH	21	17	18	18	20
	B32_LH_BB	21	14	16	16	17
	PL_B32_LH_BB	21	11	13	13	18

Table 19. Percent change in the predicted number of sturgeon caught in Albemarle Sound during winter from 2004 - 2006, 2008, & 2012 - 2014 under different effort redistribution & closure scenarios.

WINTER - STURGEON	Closed Areas	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
		No Closure (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed based on previous distribution of effort	Effort redistributed based on distance to closed area boundary
	PL	0%	-14.3%	-9.5%	-9.5%	-4.8%
	B32	0%	0.0%	0.0%	0.0%	0.0%
	LH	0%	-4.8%	-4.8%	-4.8%	-4.8%
	BB	0%	-28.6%	-19.0%	-19.0%	-4.8%
	PL_B32	0%	-14.3%	-9.5%	-9.5%	23.8%
	B32_LH	0%	-4.8%	-4.8%	-4.8%	-4.8%
	LH_BB	0%	-33.3%	-23.8%	-23.8%	-9.5%
	PL_B32_LH	0%	-19.0%	-14.3%	-14.3%	-4.8%
	B32_LH_BB	0%	-33.3%	-23.8%	-23.8%	-19.0%
	PL_B32_LH_BB	0%	-47.6%	-38.1%	-38.1%	-14.3%

Table 20. Analysis of the efficiency of different closure scenarios under effort redistribution scenarios #3 & #4 during winter between 2004 - 2006, 2008, & 2012 - 2014 in Albemarle Sound.

	Closed Areas	Total area closed (km^2)	Effort displaced (yard-days)	Reduction in the number of sturgeon takes		Ratio of sturgeon saved to area closed		Ratio of sturgeon saved to effort displaced	
				Scenario 3	Scenario 4	Scenario 3	Scenario 4	Scenario 3	Scenario 4
WINTER - STURGEON	PL	121	8828	2	1	0.0165	0.0082	0.0002	0.0001
	B32	59	600	0	0	0.0000	0.0000	0.0000	0.0000
	LH	41	720	1	1	0.0241	0.0241	0.0014	0.0014
	BB	199	14965	4	1	0.0201	0.0050	0.0003	0.0001
	PL_B32	181	9428	2	-5	0.0111	-0.0277	0.0002	-0.0005
	B32_LH	101	1320	1	1	0.0099	0.0099	0.0008	0.0008
	LH_BB	241	15685	5	2	0.0208	0.0083	0.0003	0.0001
	PL_B32_LH	222	10148	3	1	0.0135	0.0045	0.0003	0.0001
	B32_LH_BB	300	16285	5	4	0.0167	0.0133	0.0003	0.0002
	PL_B32_LH_BB	421	25113	8	3	0.0190	0.0071	0.0003	0.0001

Table 21. Predicted number of flounder caught in Albemarle Sound during winter from 2004 - 2006, 2008, & 2012 - 2014 under different effort redistribution & closure scenarios.

WINTER - FLOUNDER	Closed Areas	Scenario 0 No Closure (current scenario)	Scenario 1 Effort not redistributed	Scenario 2 Effort redistributed evenly	Scenario 3 Effort redistributed based on previous distribution of effort	Scenario 4 Effort redistributed based on distance to closed area boundary
	PL	416	408	433	433	447
	B32	416	414	416	416	415
	LH	416	412	414	414	416
	BB	416	297	332	329	401
	PL_B32	416	406	432	432	462
	B32_LH	416	410	414	414	414
	LH_BB	416	293	329	326	395
	PL_B32_LH	416	402	430	430	476
	B32_LH_BB	416	291	329	325	349
	PL_B32_LH_BB	416	283	344	338	476

Table 22. Percent change in the predicted number of flounder caught in Albemarle Sound during winter from 2004 - 2006, 2008, & 2012 - 2014 under different effort redistribution & closure scenarios.

WINTER - FLOUNDER	Closed Areas	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
		No Closure (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed based on previous distribution of effort	Effort redistributed based on distance to closed area boundary
	PL	0%	-1.9%	4.1%	4.1%	7.5%
	B32	0%	-0.5%	0.0%	0.0%	-0.2%
	LH	0%	-1.0%	-0.5%	-0.5%	0.0%
	BB	0%	-28.6%	-20.2%	-20.9%	-3.6%
	PL_B32	0%	-2.4%	3.8%	3.8%	11.1%
	B32_LH	0%	-1.4%	-0.5%	-0.5%	-0.5%
	LH_BB	0%	-29.6%	-20.9%	-21.6%	-5.0%
	PL_B32_LH	0%	-3.4%	3.4%	3.4%	14.4%
	B32_LH_BB	0%	-30.0%	-20.9%	-21.9%	-16.1%
	PL_B32_LH_BB	0%	-32.0%	-17.3%	-18.8%	14.4%

Table 23. Predicted number of American shad caught in Albemarle Sound during winter from 2004 - 2006, 2008, & 2012 - 2014 under different effort redistribution & closure scenarios.

WINTER - AMERICAN SHAD		Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	Closed Areas	**No Closure (current scenario)**	**Effort not redistributed**	**Effort redistributed evenly**	**Effort redistributed based on previous distribution of effort**	**Effort redistributed based on distance to closed area boundary**
	PL	804	782	823	830	784
	B32	804	804	807	807	804
	LH	804	803	806	807	803
	BB	804	797	866	883	857
	PL_B32	804	782	826	833	791
	B32_LH	804	803	809	810	803
	LH_BB	804	796	868	886	855
	PL_B32_LH	804	781	828	836	785
	B32_LH_BB	804	796	871	890	830
	PL_B32_LH_BB	804	774	901	925	889

Table 24. Percent change in the predicted number of American shad caught in Albemarle Sound during winter from 2004 - 2006, 2008, & 2012 - 2014 under different effort redistribution & closure scenarios.

WINTER - AMERICAN SHAD		Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	Closed Areas	**No Closure (current scenario)**	**Effort not redistributed**	**Effort redistributed evenly**	**Effort redistributed based on previous distribution of effort**	**Effort redistributed based on distance to closed area boundary**
	PL	0%	-2.7%	2.4%	3.2%	-2.5%
	B32	0%	0.0%	0.4%	0.4%	0.0%
	LH	0%	-0.1%	0.2%	0.4%	-0.1%
	BB	0%	-0.9%	7.7%	9.8%	6.6%
	PL_B32	0%	-2.7%	2.7%	3.6%	-1.6%
	B32_LH	0%	-0.1%	0.6%	0.7%	-0.1%
	LH_BB	0%	-1.0%	8.0%	10.2%	6.3%
	PL_B32_LH	0%	-2.9%	3.0%	4.0%	-2.4%
	B32_LH_BB	0%	-1.0%	8.3%	10.7%	3.2%
	PL_B32_LH_BB	0%	-3.7%	12.1%	15.0%	10.6%

HIGHER RESOLUTION MAPS OF TELEMETERED STURGEON IN THE CAPE FEAR & BRUNSWICK RIVERS

EQUAL INTERVAL CLASSIFICATION

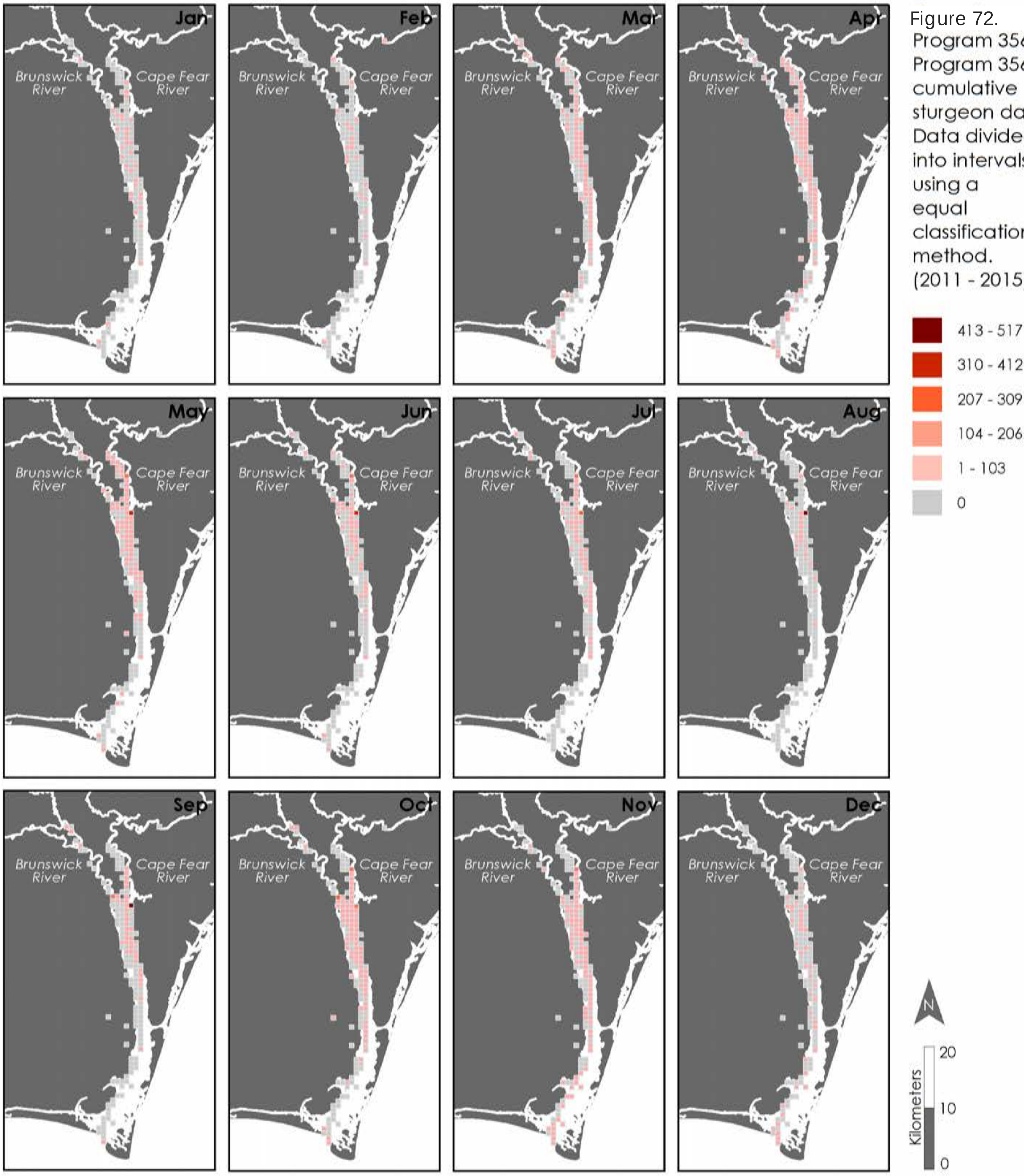


Figure 72. Program 356 Program 356 cumulative sturgeon days; Data divided into intervals using a equal classification method. (2011 - 2015)

QUANTILE CLASSIFICATION

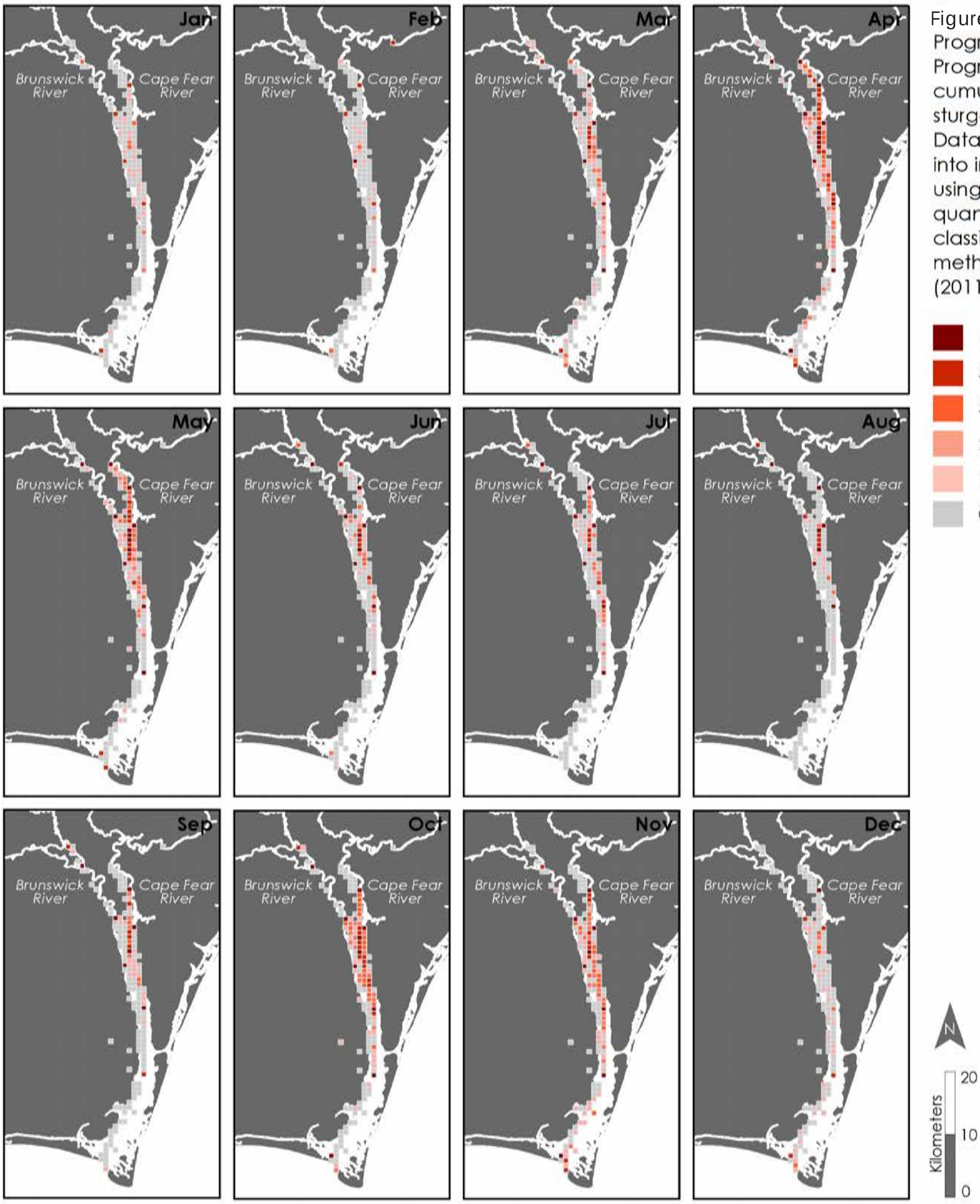


Figure 73. Program 356 Program 356 cumulative sturgeon days; Data divided into intervals using a quantile classification method. (2011 - 2015)

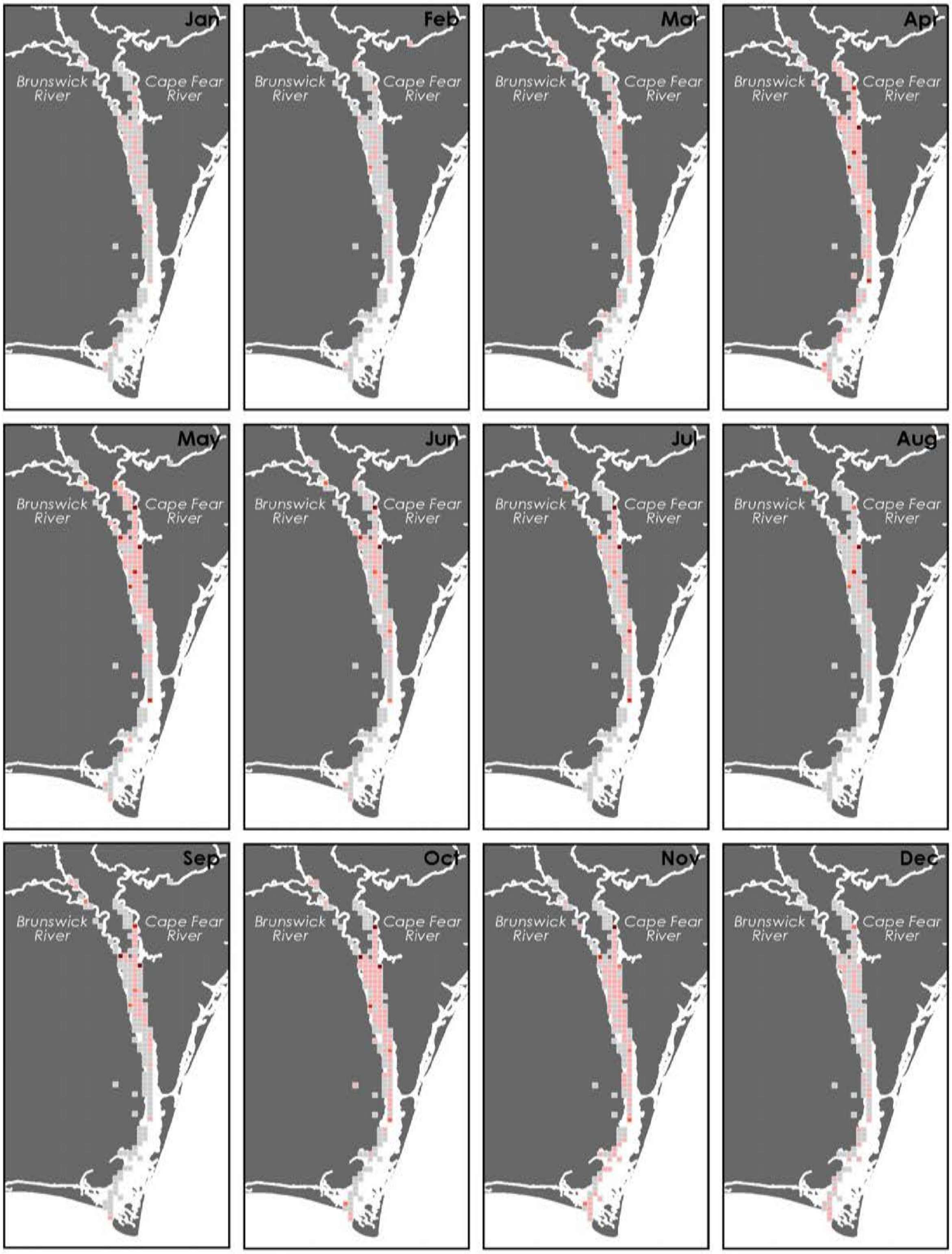


Figure 74. Program 356 cumulative sturgeon days; Data divided into intervals using a manual classification method. (2011 - 2015)

Table 25. Observed sturgeon bycatch by gear type in Albemarle Sound (2004 - 2006, 2008, & 2012 - 2014)

STURGEON - ALBEMARLE SOUND - ALL MONTHS*							
Gear Type	# of records	# of records with sturgeon bycatch	Total sturgeon bycatch	% of records with sturgeon bycatch	Average number of sturgeon caught per record	Total fishing effort (yard-days)	Total sturgeon bycatch/Total Fishing Effort
Float Nets	265	26	43	9.81%	0.162	166683	0.00026
Sink Nets	1119	81	123	7.24%	0.110	910963	0.00014
Other	1	0	0	0%	0	500	0.00000

*For each column, the highest value is shown in red text.

Figure 75. Observed trips by gear type in Albemarle Sound (2004 - 2006, 2008, & 2012 - 2014)

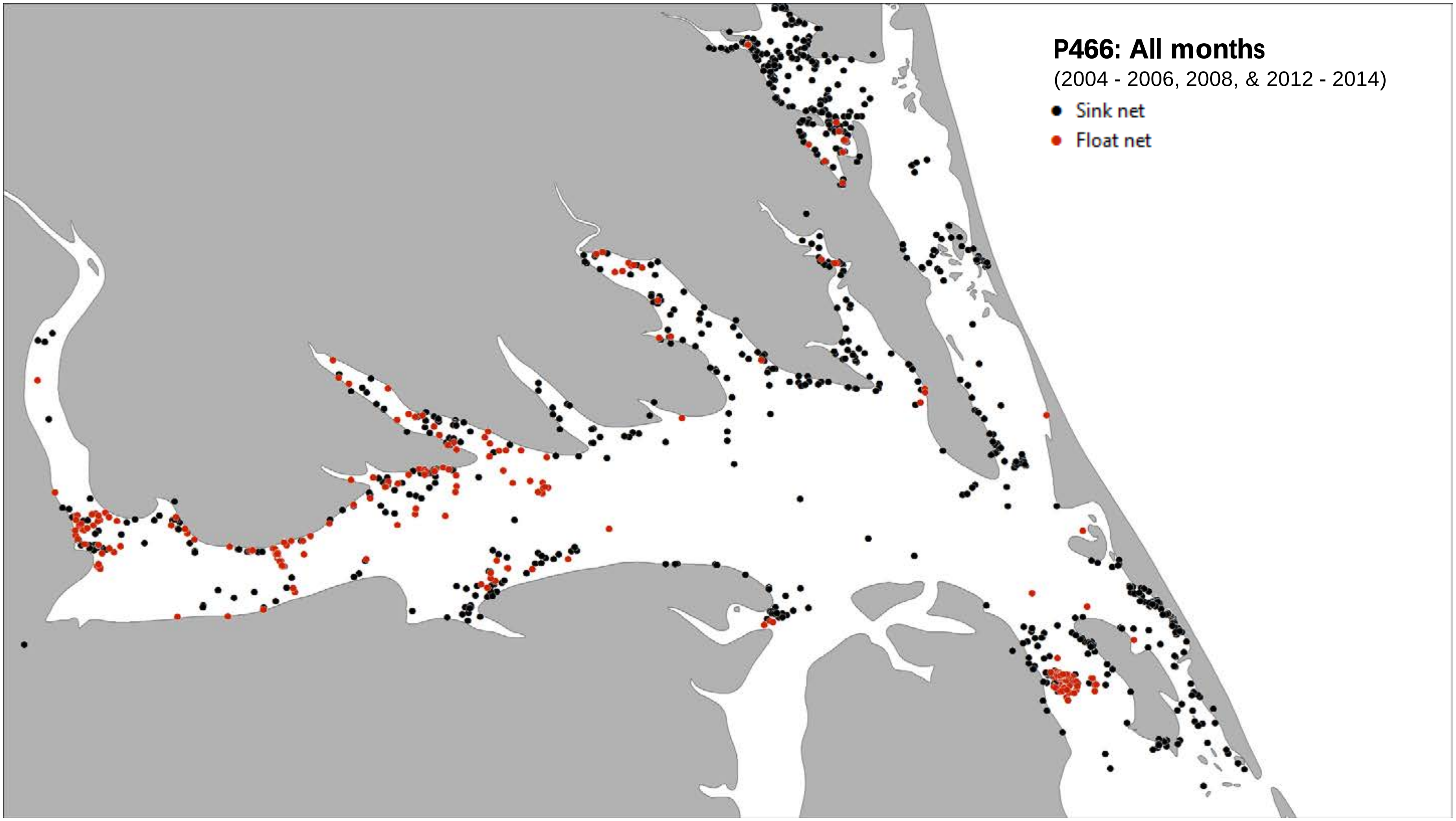


Figure 76. Observed trips and recorded sturgeon bycatch by gear type in Albemarle Sound (2004 - 2006, 2008, & 2012 - 2014)

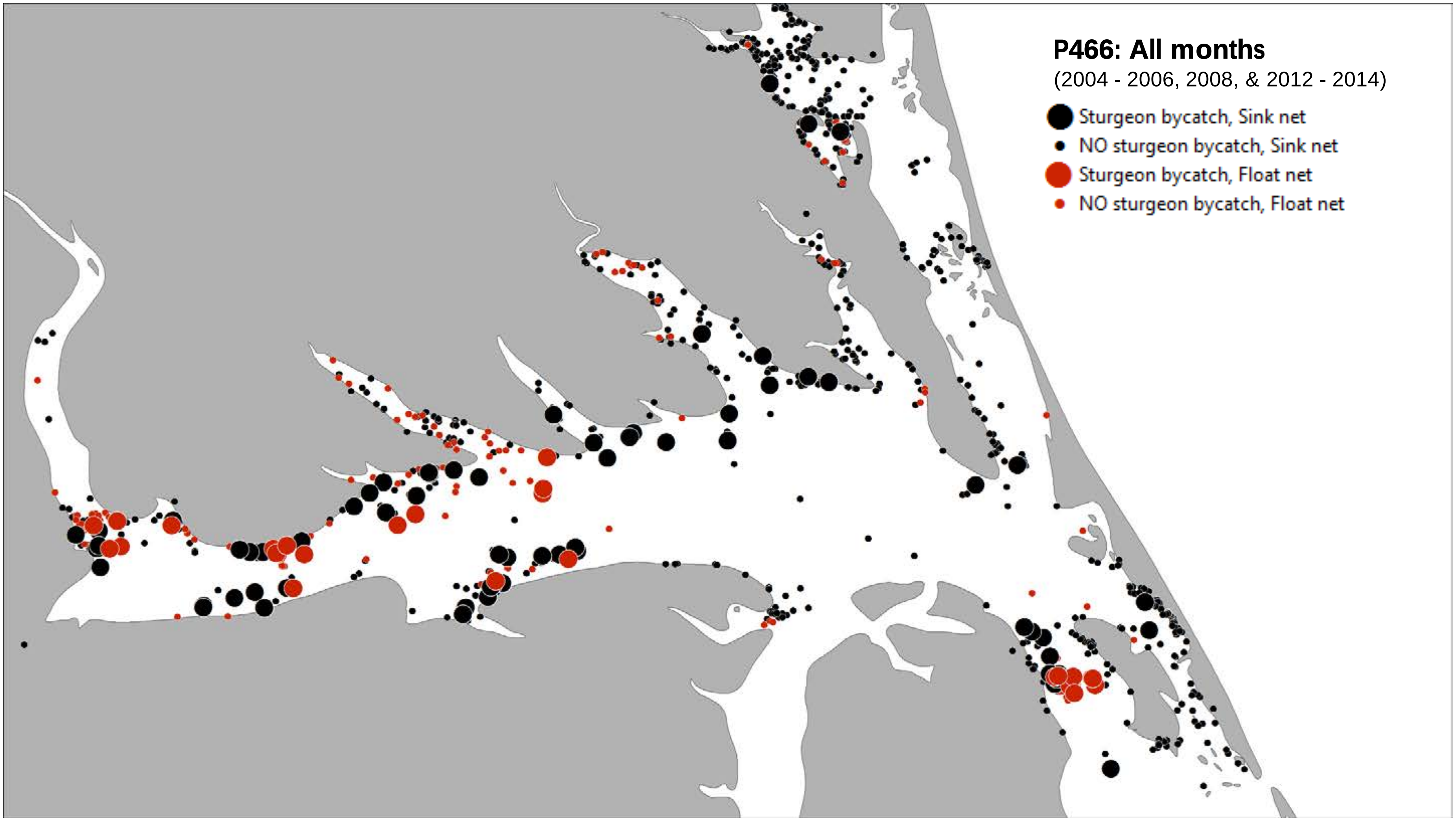


Figure 77. Observed trips by gear type in Albemarle Sound (2004 - 2006, 2008, & 2012 - 2014) with zoom in of the mouth of the Chowan River

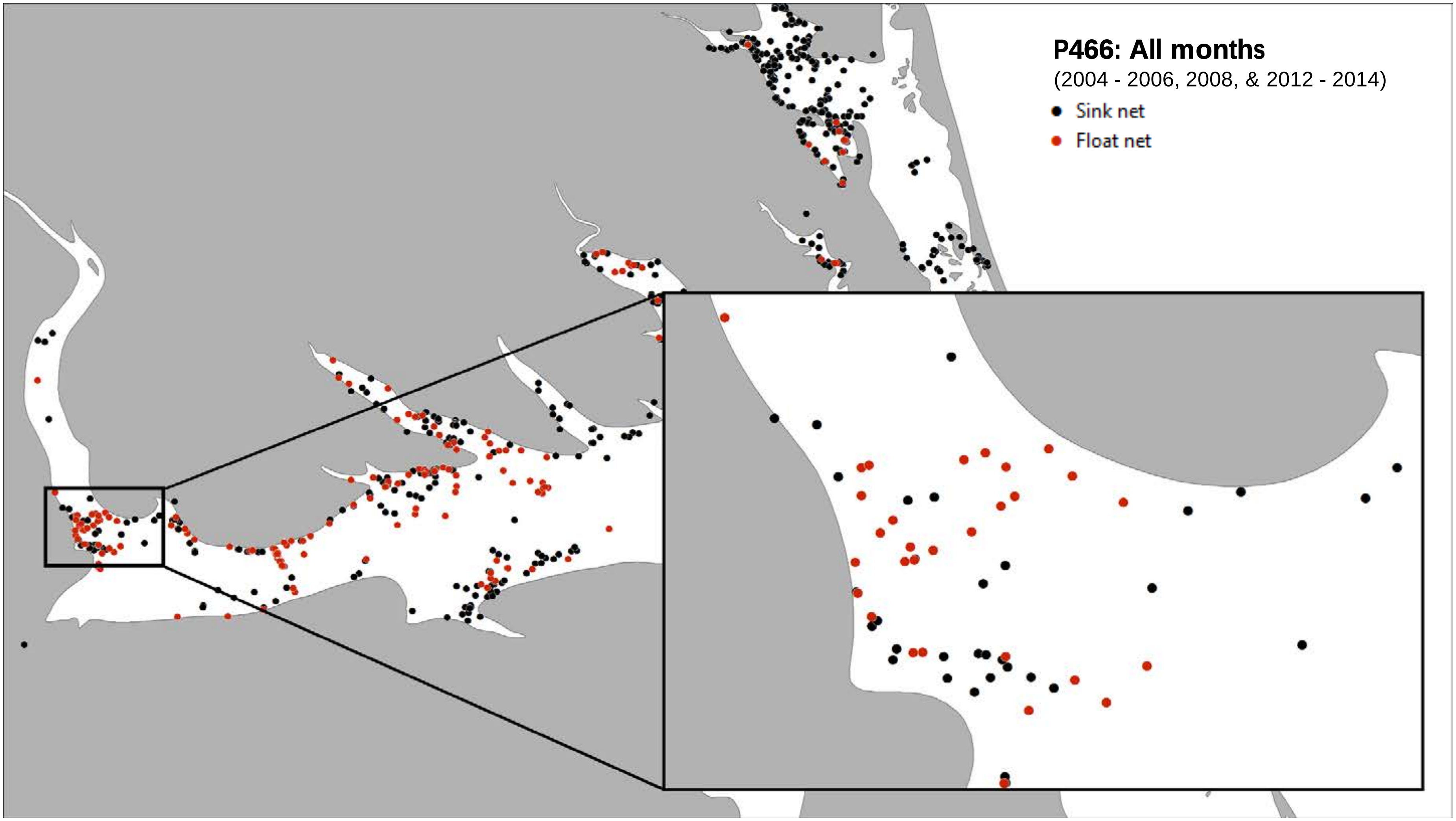


Figure 78. Observed trips and recorded sturgeon bycatch by gear type in Albemarle Sound (2004 - 2006, 2008, & 2012 - 2014) with zoom in of the mouth of the Chowan River

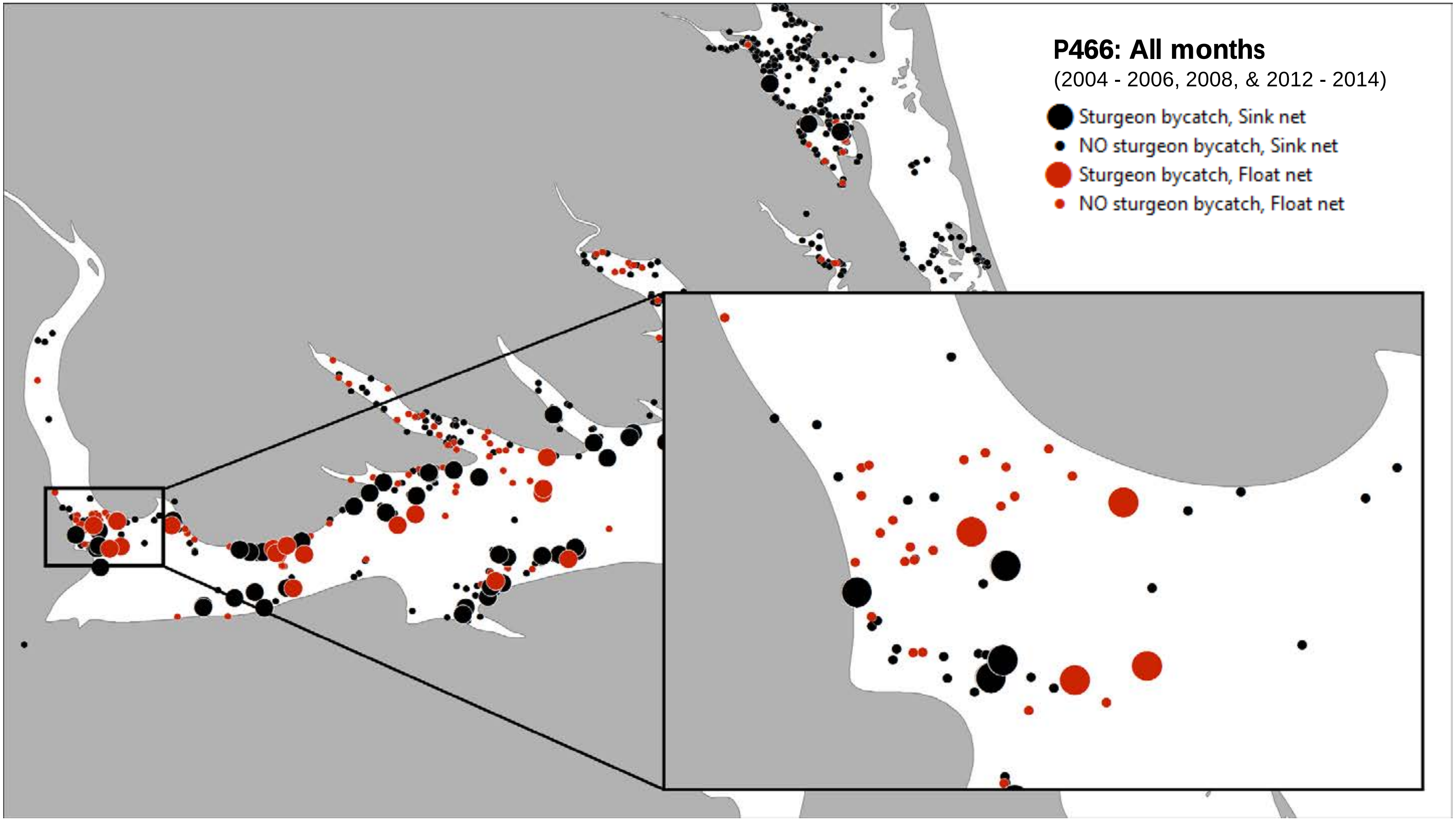


Figure 79. Observed trips by gear type in Albemarle Sound (2004 - 2006, 2008, & 2012 - 2014) with zoom in of Currituck Sound

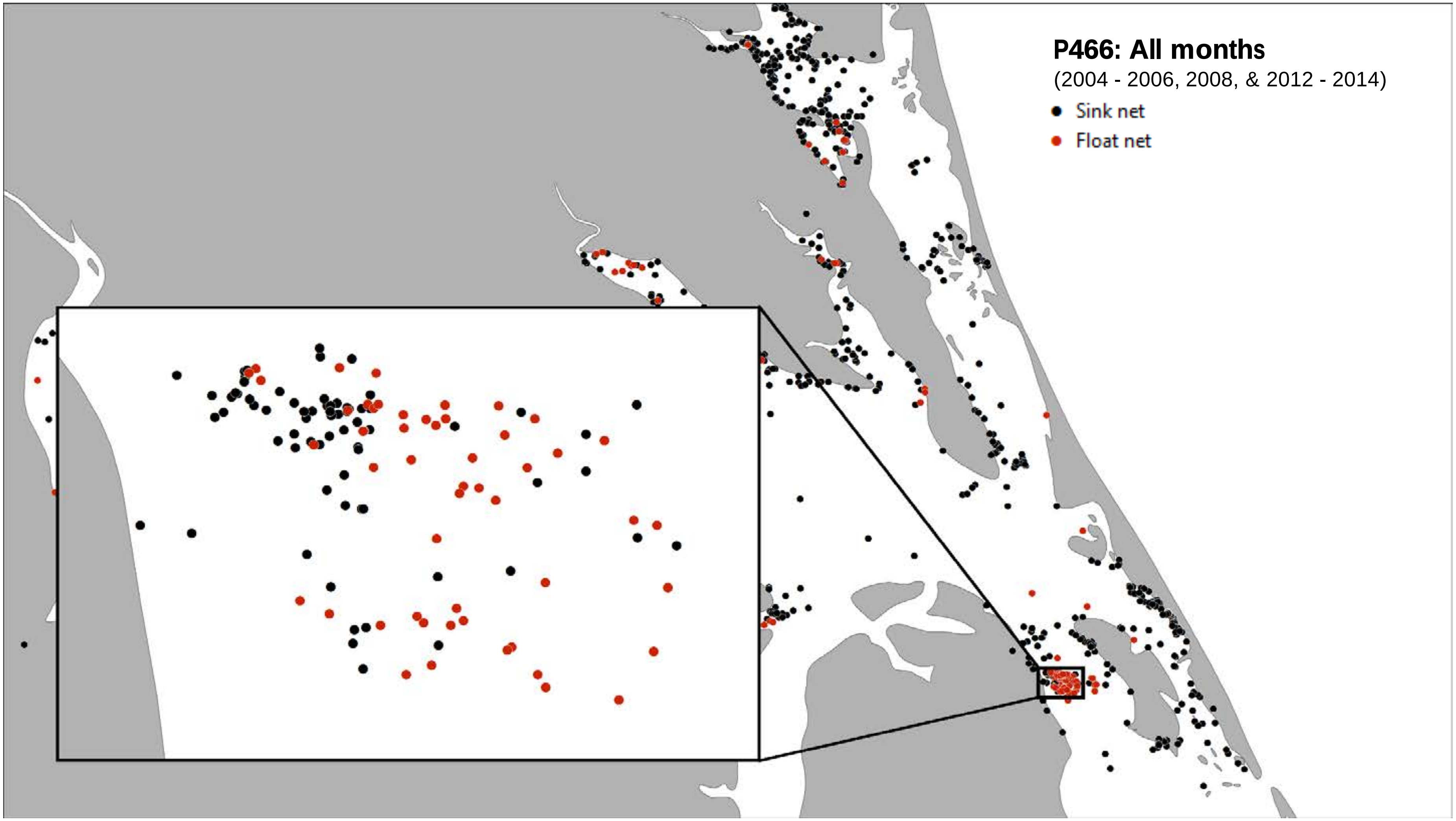


Figure 80. Observed trips and recorded sturgeon bycatch by gear type in Albemarle Sound (2004 - 2006, 2008, & 2012 - 2014) with zoom in of the Currituck Sound

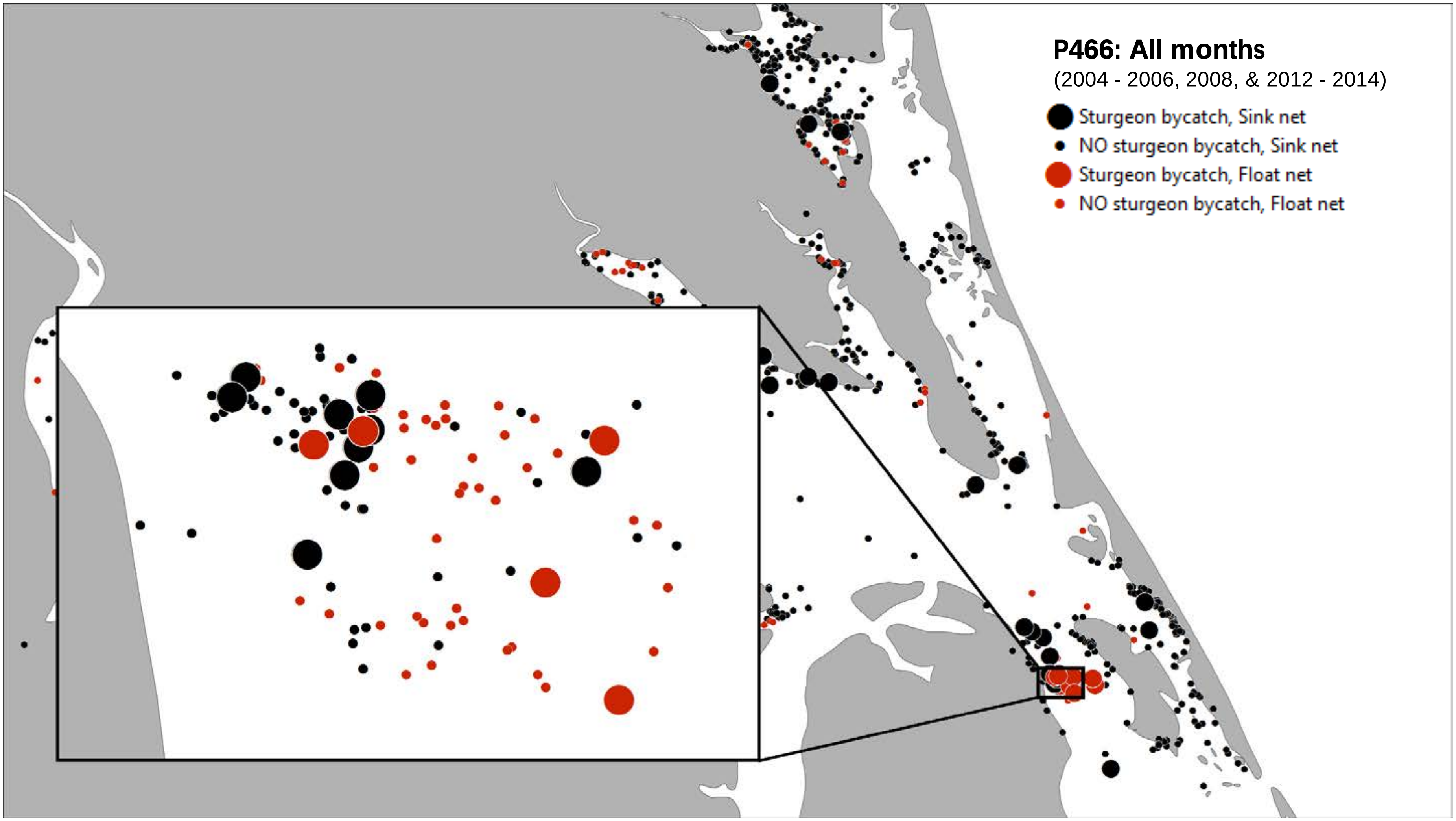


Table 26. Observed sturgeon bycatch by gear type in Albemarle Sound in February - April (2004 - 2006, 2008, & 2012 - 2014)

STURGEON - ALBEMARLE SOUND - SPRING *							
Gear Type	**# of records**	**# of records with sturgeon bycatch**	**Total sturgeon bycatch**	**% of records with sturgeon bycatch**	**Average number of sturgeon caught per record**	**Total fishing effort (yard-days)**	**Total sturgeon bycatch/Total Fishing Effort**
Float Nets	156	20	35	12.82%	0.224	84781	0.00041
Sink Nets	350	36	60	10.29%	0.171	250816	0.00024
Other	0	0	0	n/a	n/a	0	n/a

*For each column, the highest value is shown in red text.

Figure 81. Observed trips by gear type in Albemarle Sound in February - April (2004 - 2006, 2008, & 2012 - 2014)

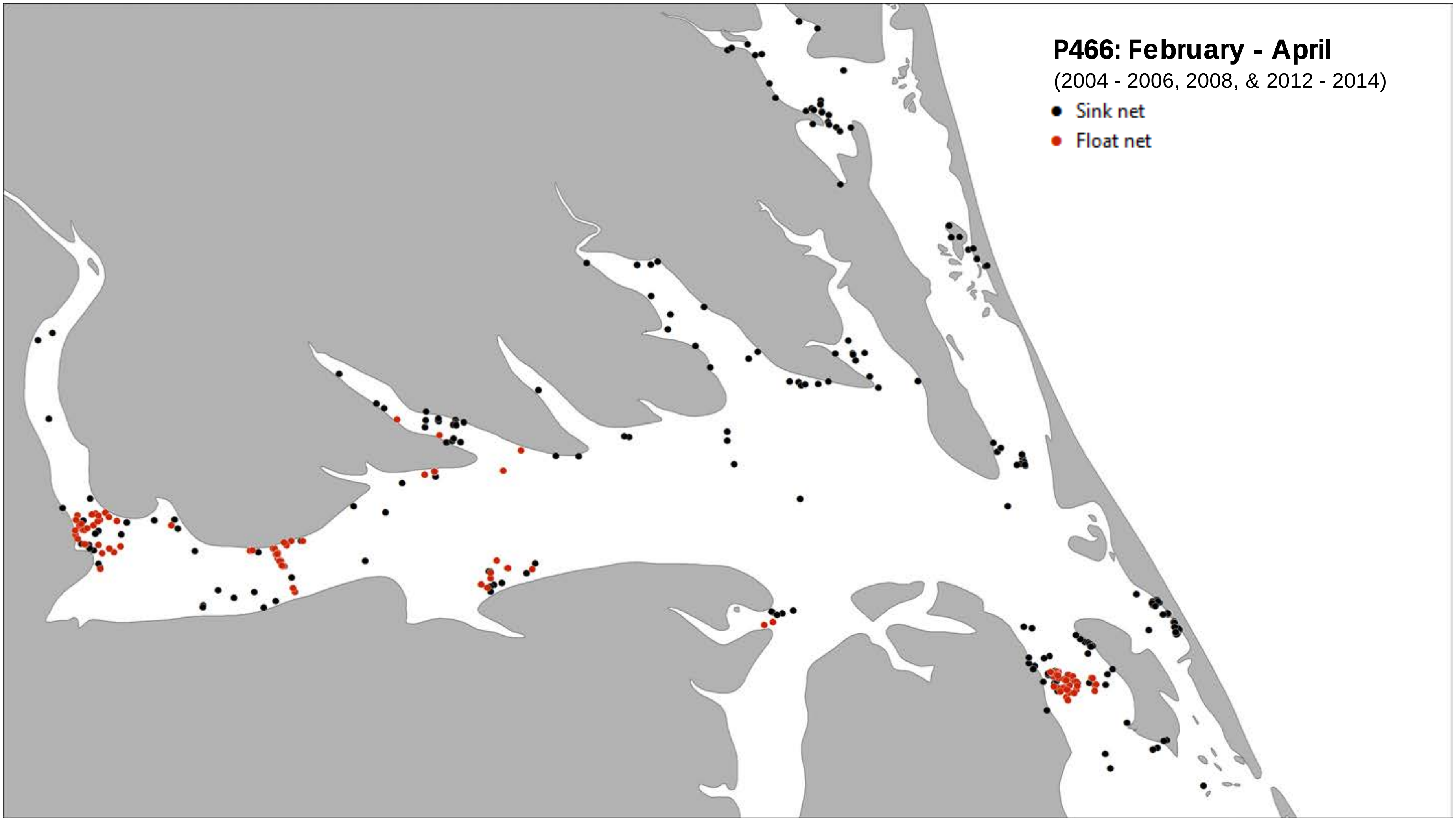


Figure 82. Observed trips and recorded sturgeon bycatch by gear type in Albemarle Sound in February - April (2004 - 2006, 2008, & 2012 - 2014)

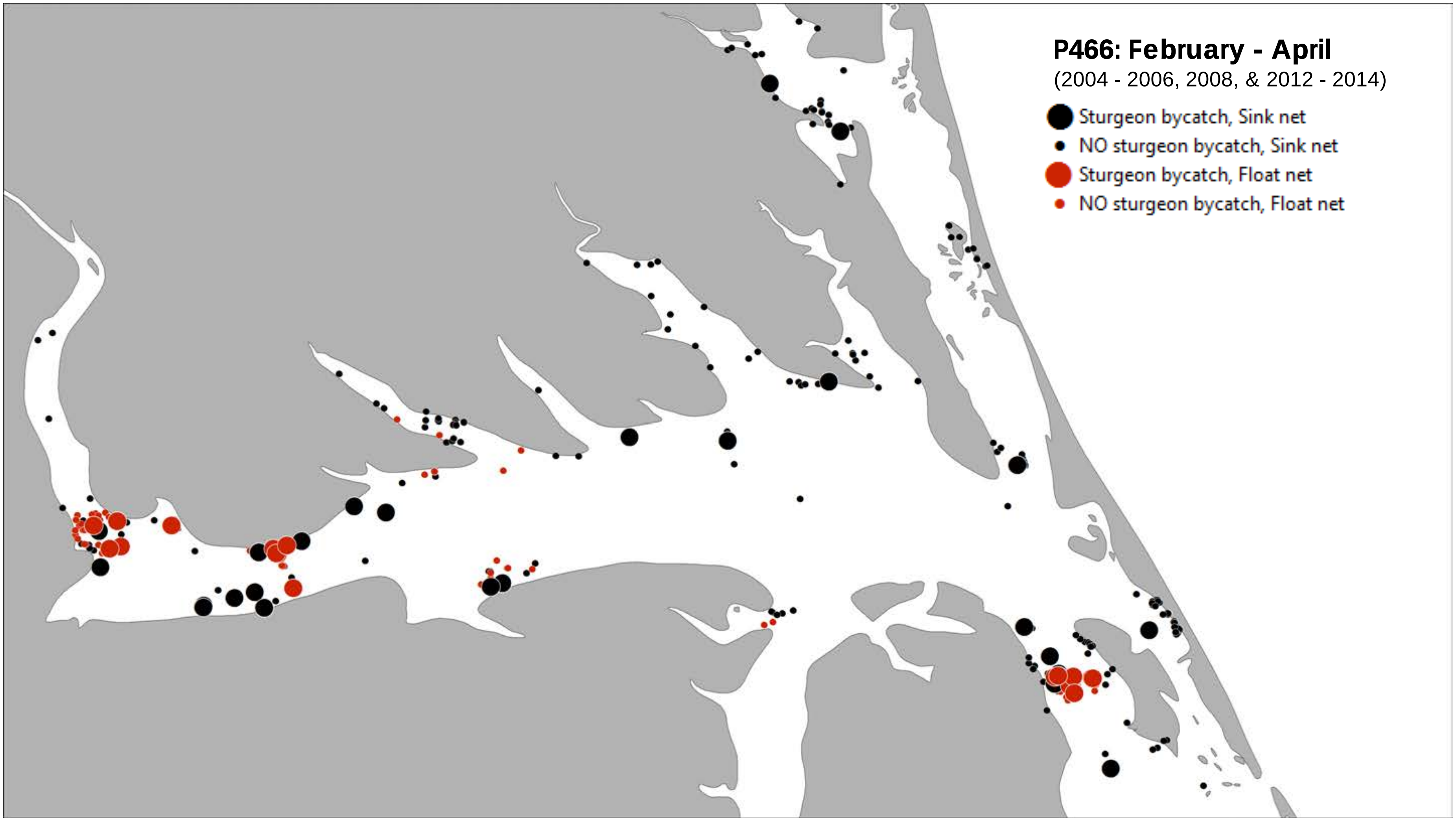


Figure 83. Observed trips by gear type in Albemarle Sound in February - April (2004 - 2006, 2008, & 2012 - 2014) with zoom in of the mouth of the Chowan River

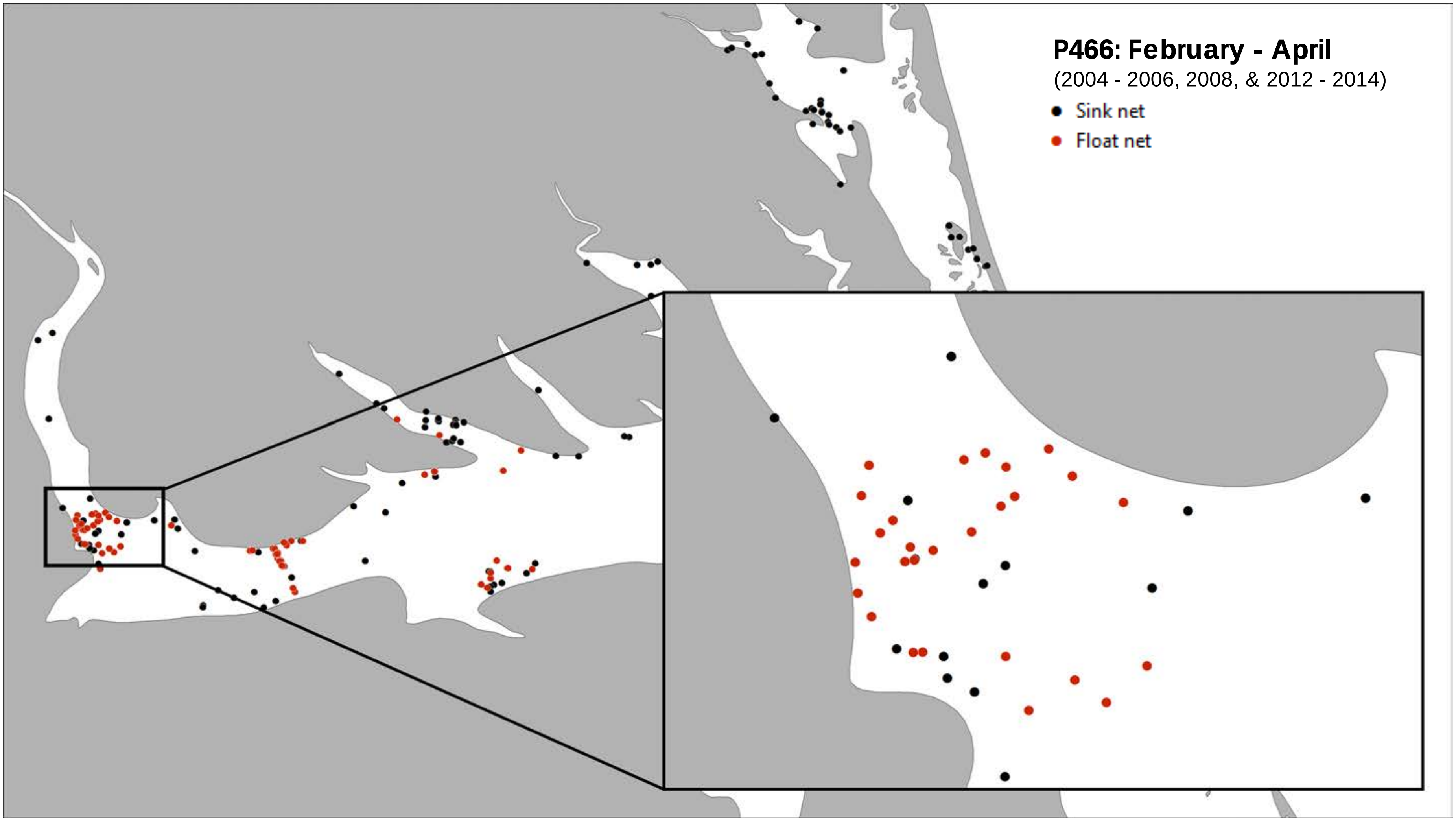


Figure 84. Observed trips and recorded sturgeon bycatch by gear type in Albemarle Sound in February - April (2004 - 2006, 2008, & 2012 - 2014) with zoom in of the mouth of the Chowan River

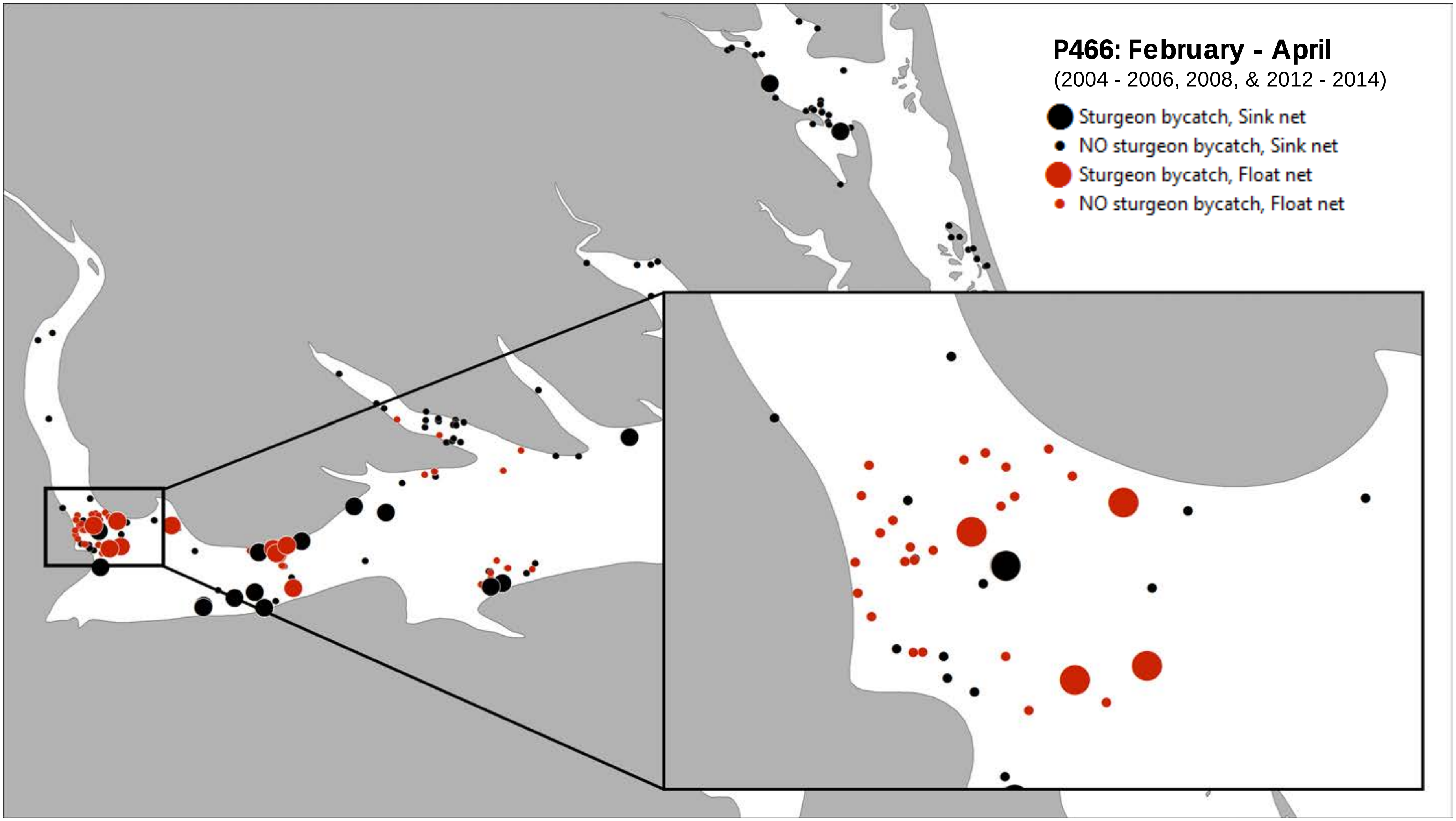


Figure 85. Observed trips by gear type in Albemarle Sound in February - April (2004 - 2006, 2008, & 2012 - 2014) with zoom in of Currituck Sound

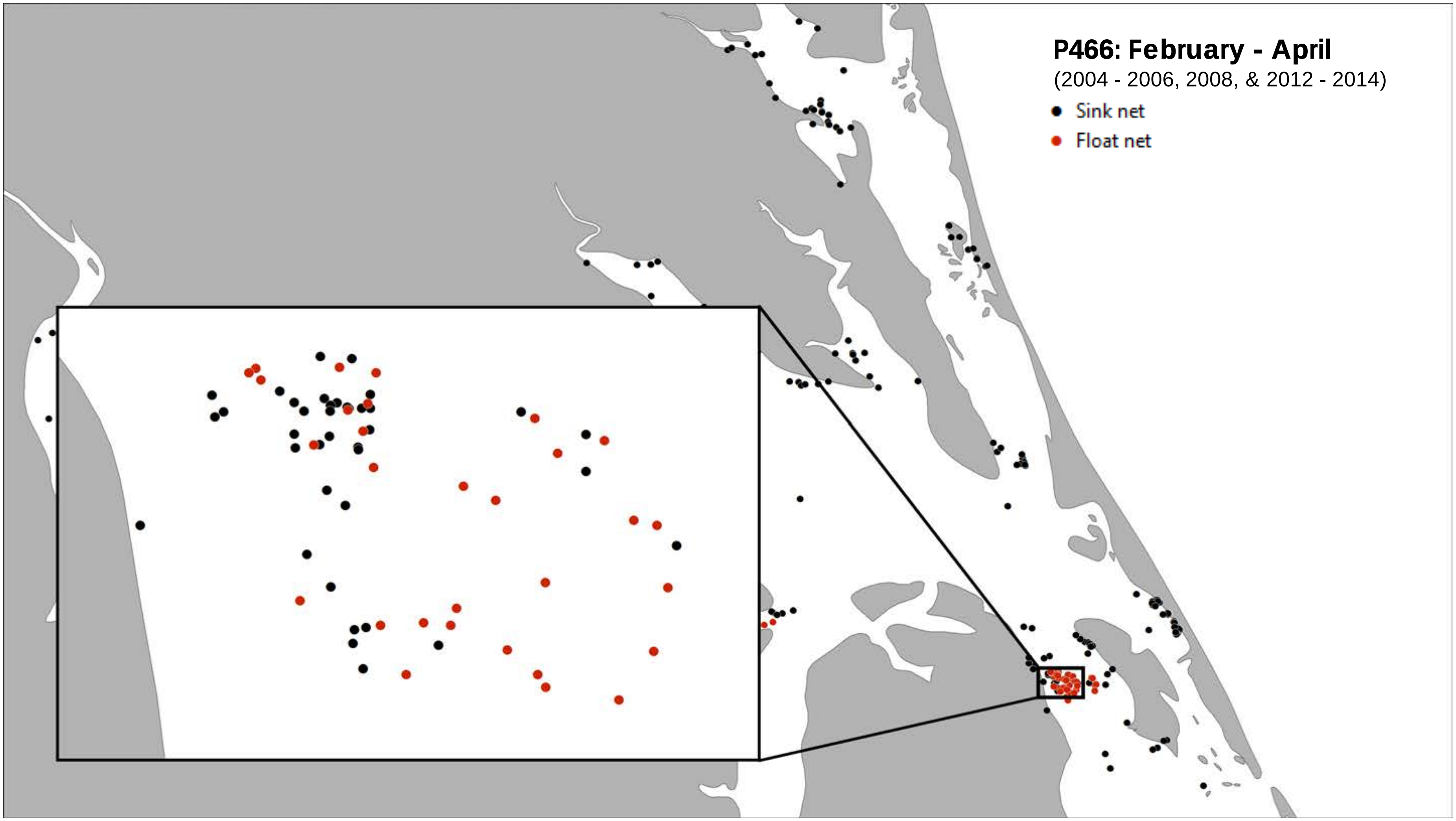


Figure 86. Observed trips and recorded sturgeon bycatch by gear type in Albemarle Sound in February - April (2004 - 2006, 2008, & 2012 - 2014) with zoom in of the Currituck Sound

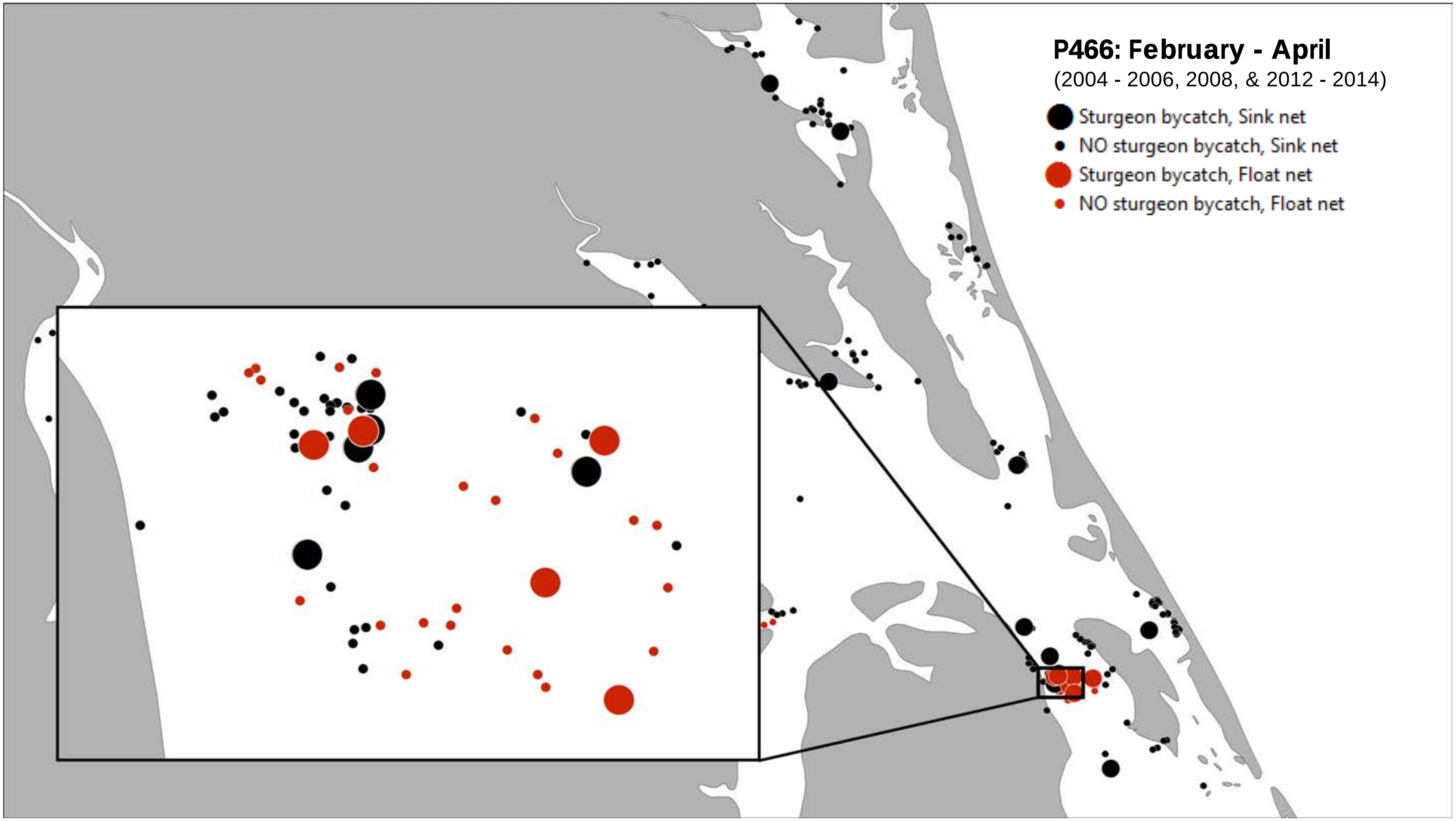


Table 27. Observed sturgeon bycatch by gear type in Pamlico Sound (2003- 2014)

STURGEON - PAMLICO SOUND - ALL MONTHS *							
Gear Type	# of records	# of records with sturgeon bycatch	Total sturgeon bycatch	% of records with sturgeon bycatch	Average number of sturgeon caught per record	Total fishing effort (yard-days)	Total sturgeon bycatch/Total Fishing Effort
Float Nets	493	2	2	0.41%	0.004	141832	0.00001
Sink Nets	5100	57	61	1.12%	0.012	3223438	0.00002
Other	30	0	0	0%	0	2412	0.00000

*For each column, the highest value is shown in red text.

Figure 87. Observed trips by gear type in Pamlico Sound (2003 - 2014)

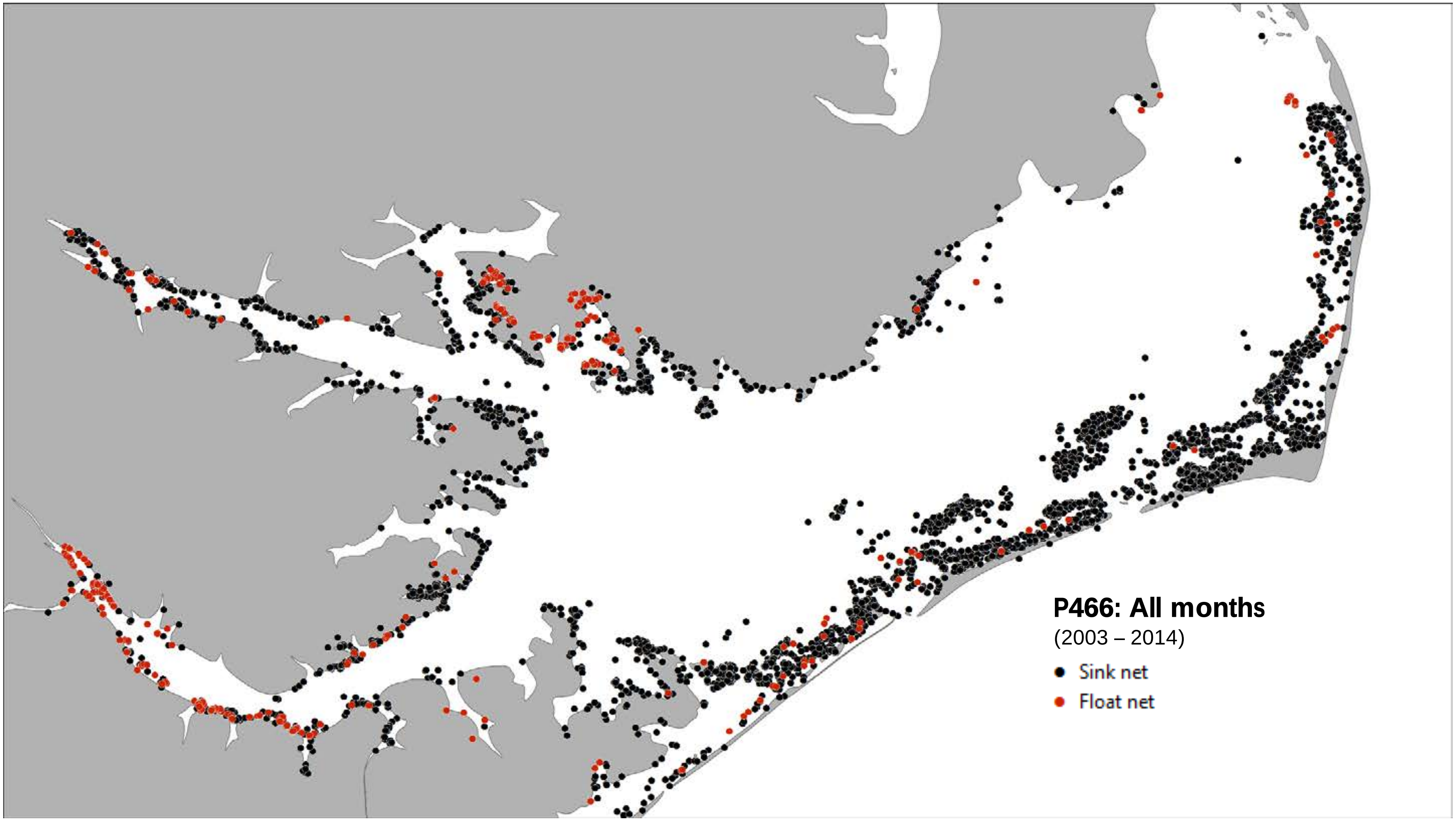


Figure 88. Observed trips and recorded sturgeon bycatch by gear type in Pamlico Sound (2003 - 2014)

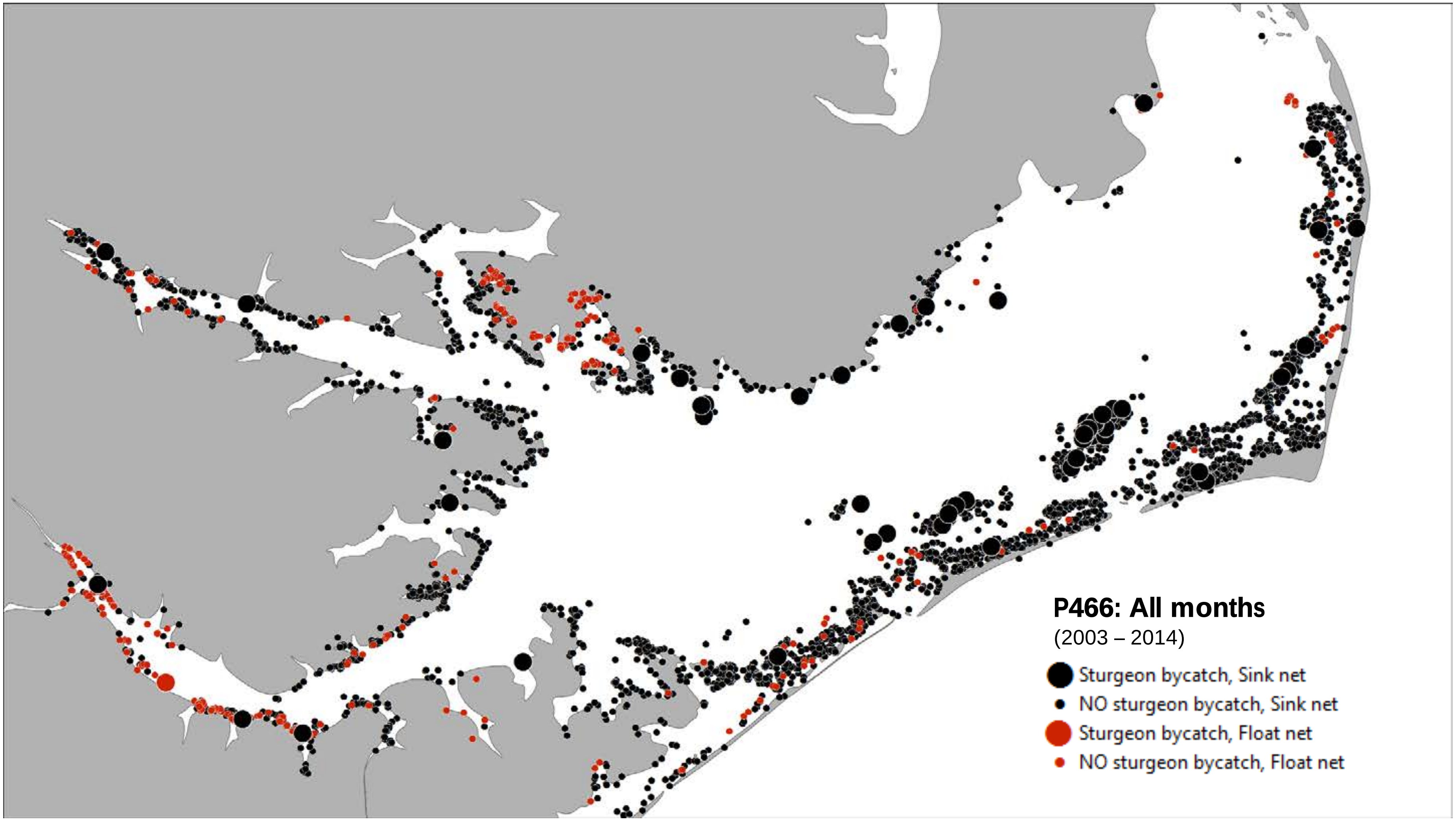


Table 26. Observed sturgeon bycatch by gear type in Pamlico Sound in February – April (2003- 2014)

STURGEON - PAMLICO SOUND - SPRING *							
Gear Type	# of records	# of records with sturgeon bycatch	Total sturgeon bycatch	% of records with sturgeon bycatch	Average number of sturgeon caught per record	Total fishing effort (yard-days)	Total sturgeon bycatch/Total Fishing Effort
Float Nets	228	2	2	0.88%	0.009	103816	0.00002
Sink Nets	641	3	3	0.47%	0.005	325840	0.00001
Other	12	0	0	0%	0	641	0.00000

*For each column, the highest value is shown in red text.

Figure 89. Observed trips by gear type in Pamlico Sound in February - April (2003 - 2014)

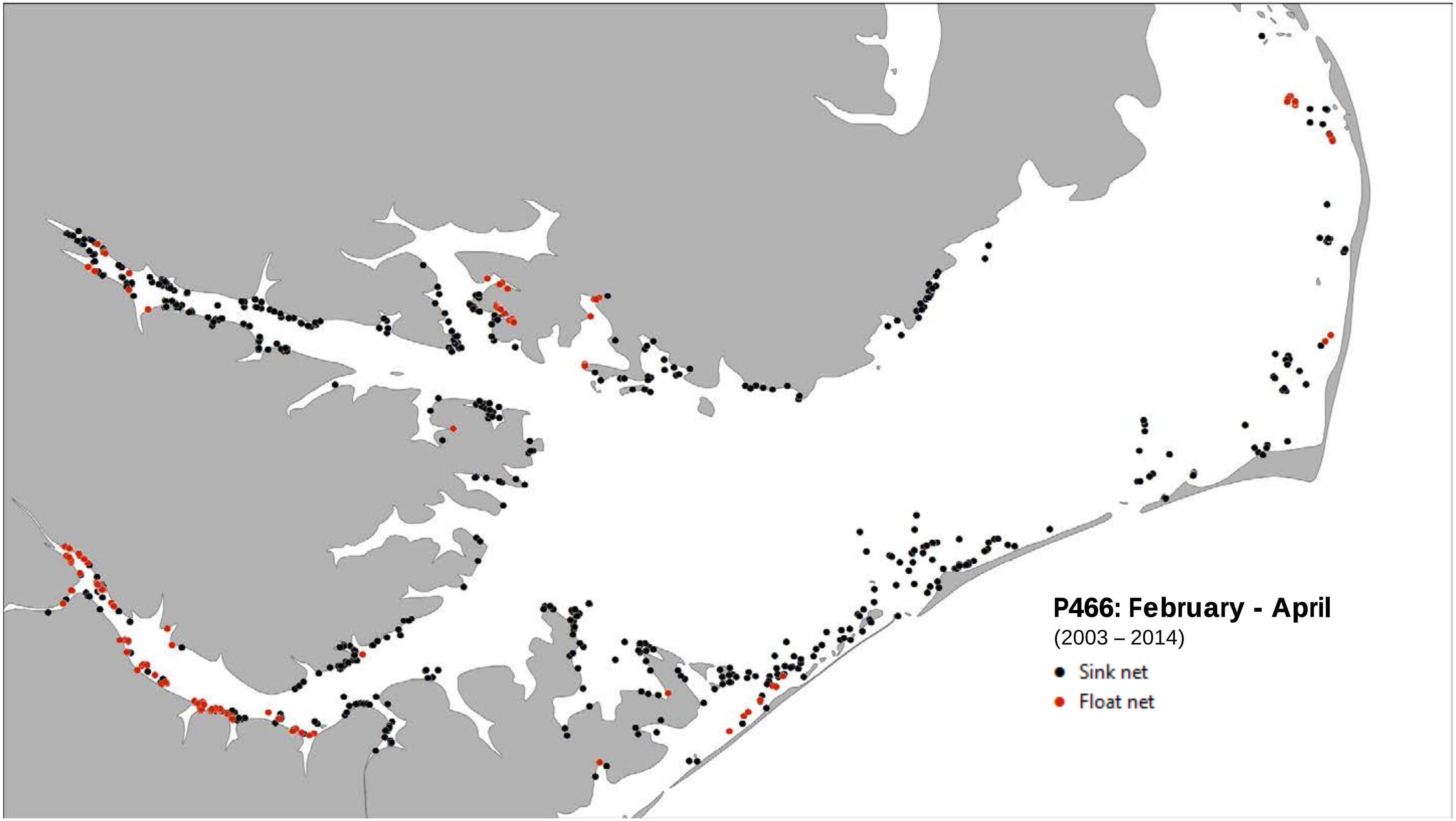
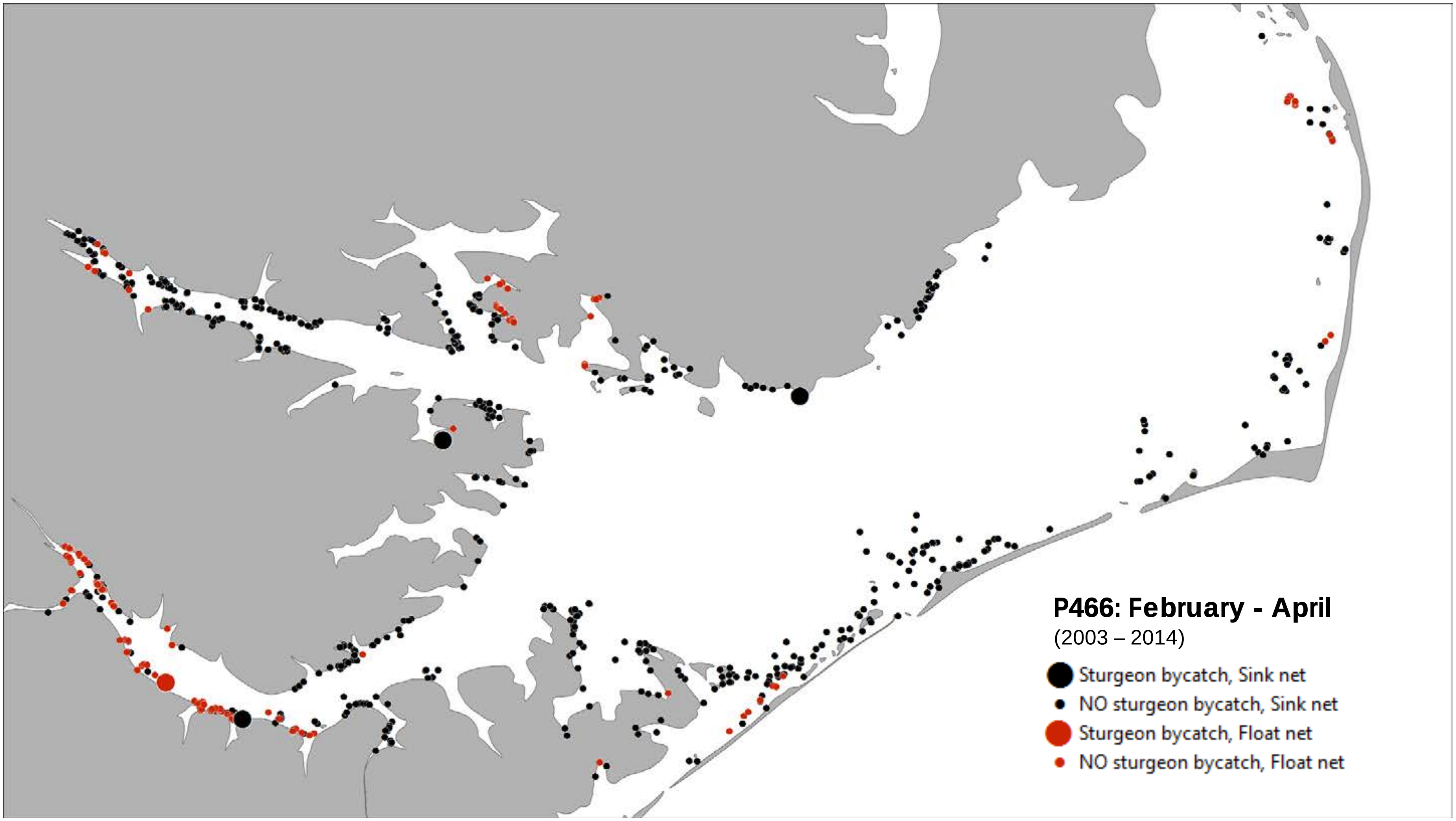


Figure 90. Observed trips and recorded sturgeon bycatch by gear type in Pamlico Sound in February - April (2003 - 2014)



8. Appendix B: Sea Turtle Bycatch and Distribution Supporting Figures

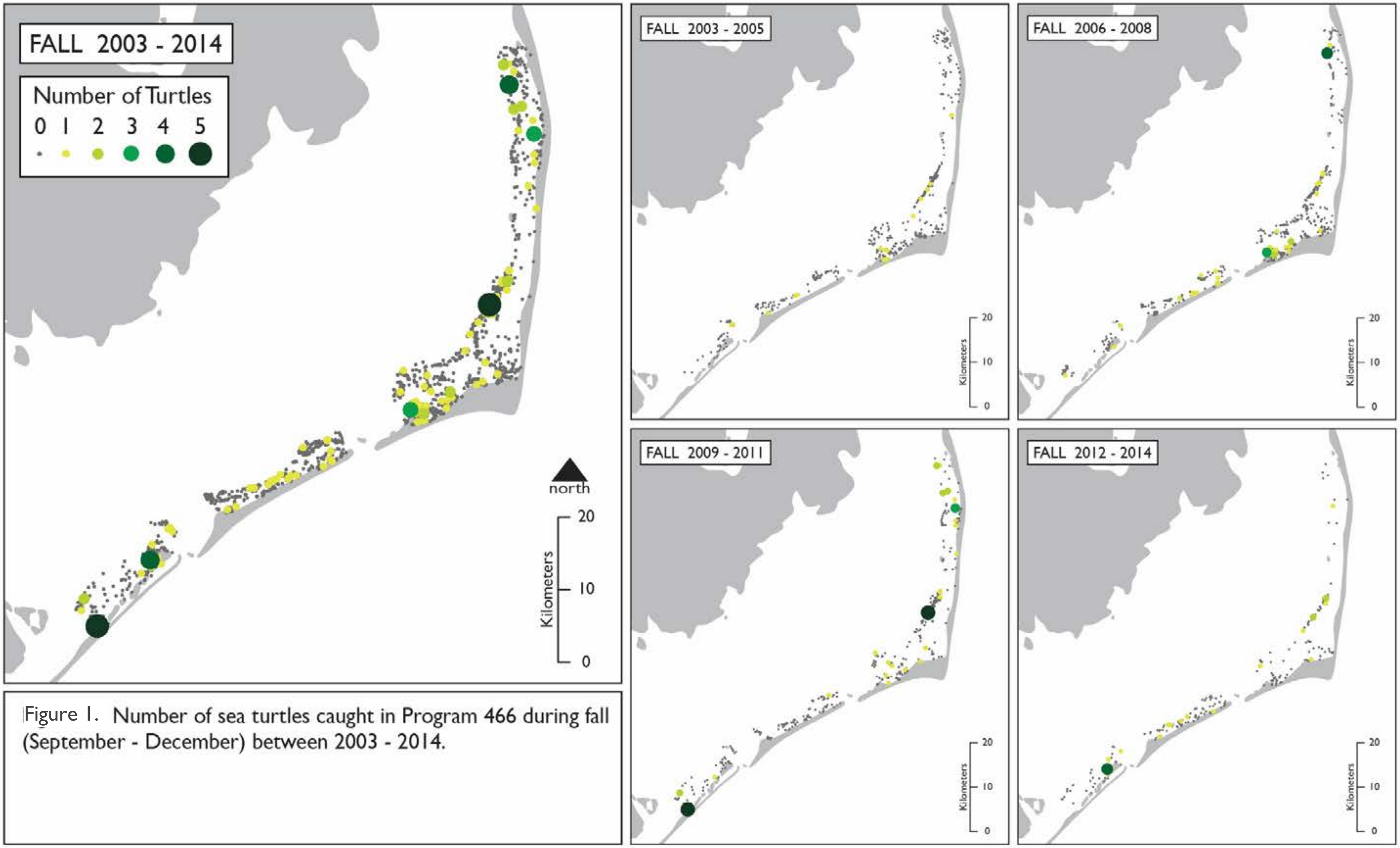


Figure 1. Number of sea turtles caught in Program 466 during fall (September - December) between 2003 - 2014.

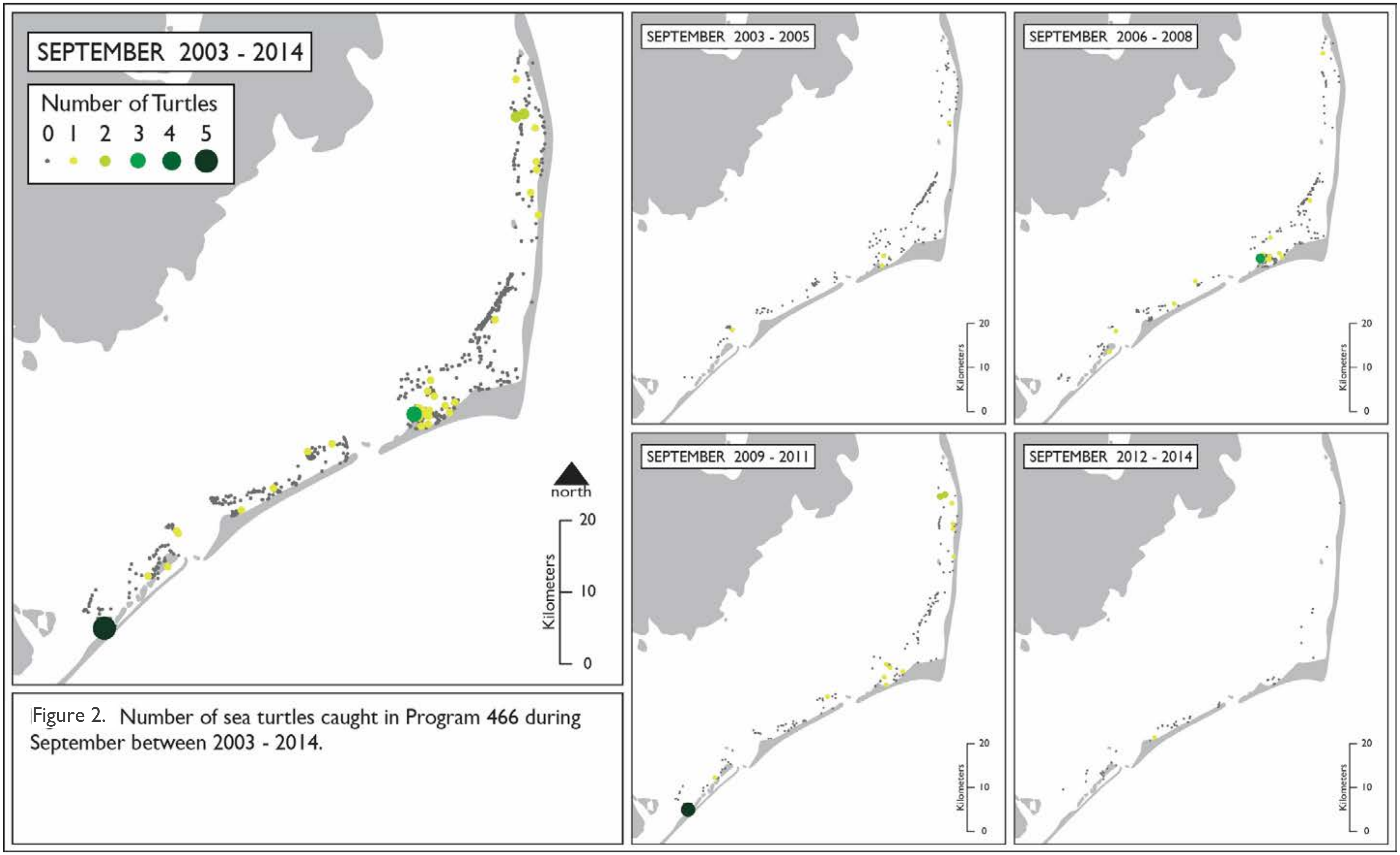


Figure 2. Number of sea turtles caught in Program 466 during September between 2003 - 2014.

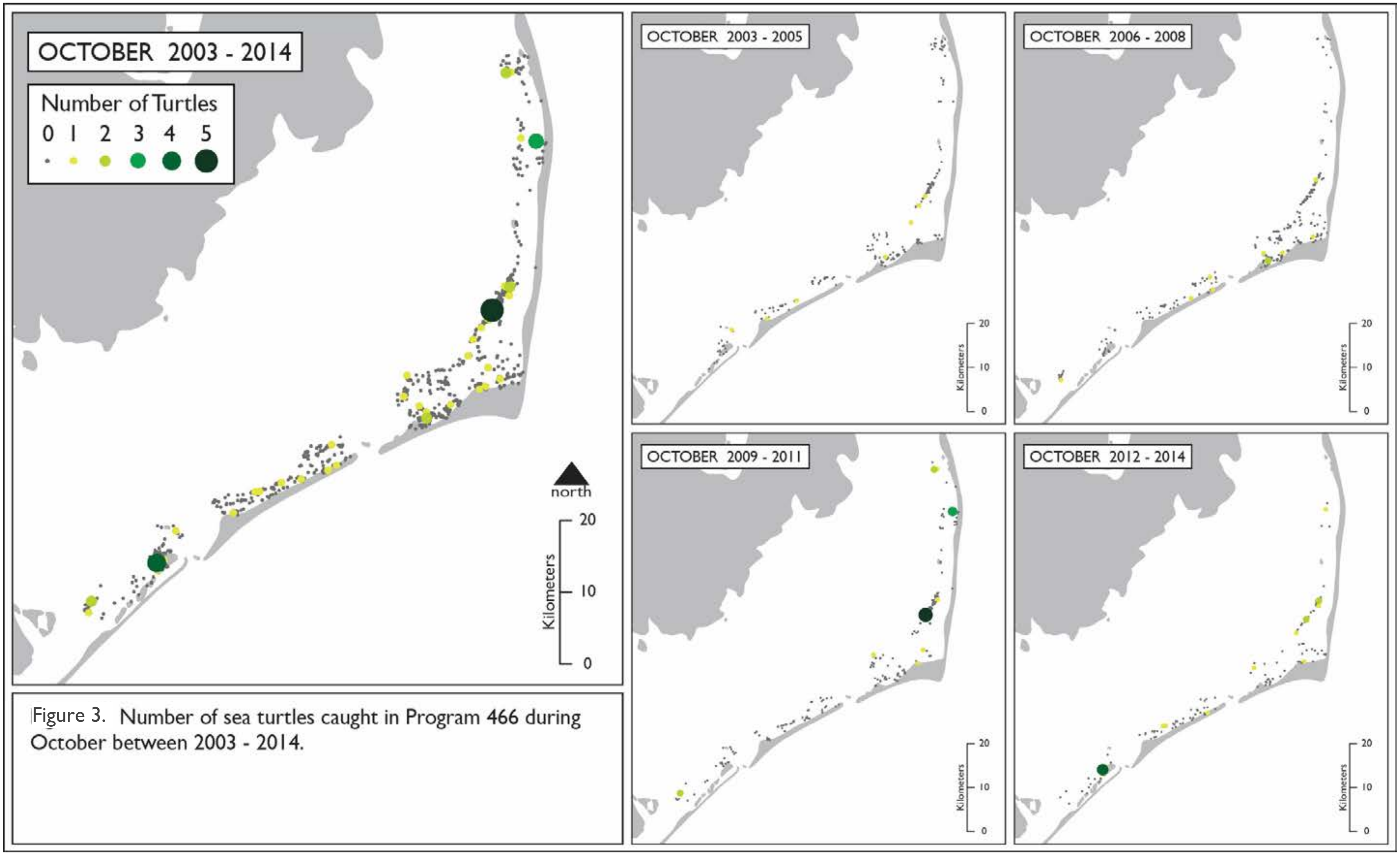


Figure 3. Number of sea turtles caught in Program 466 during October between 2003 - 2014.

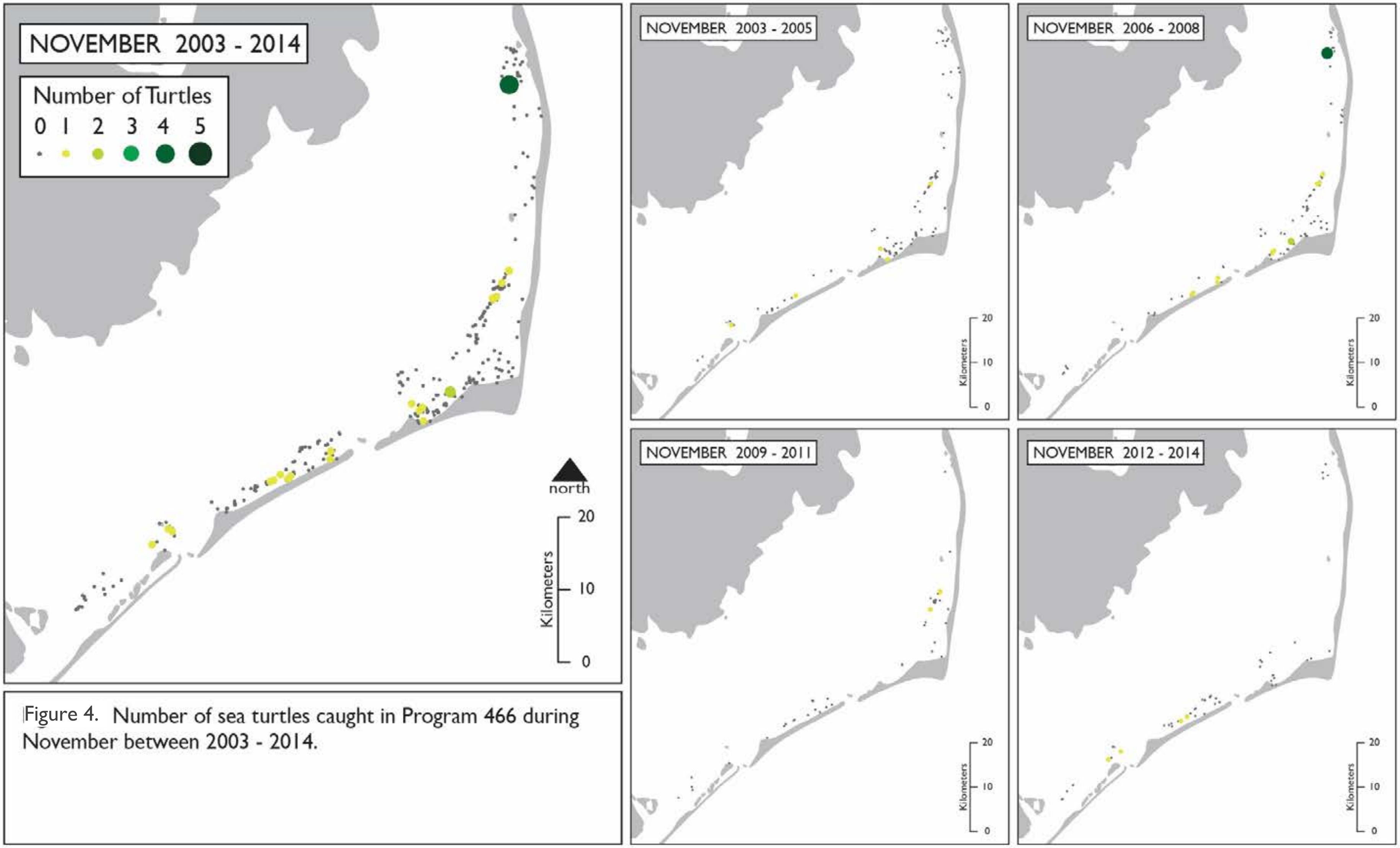


Figure 4. Number of sea turtles caught in Program 466 during November between 2003 - 2014.

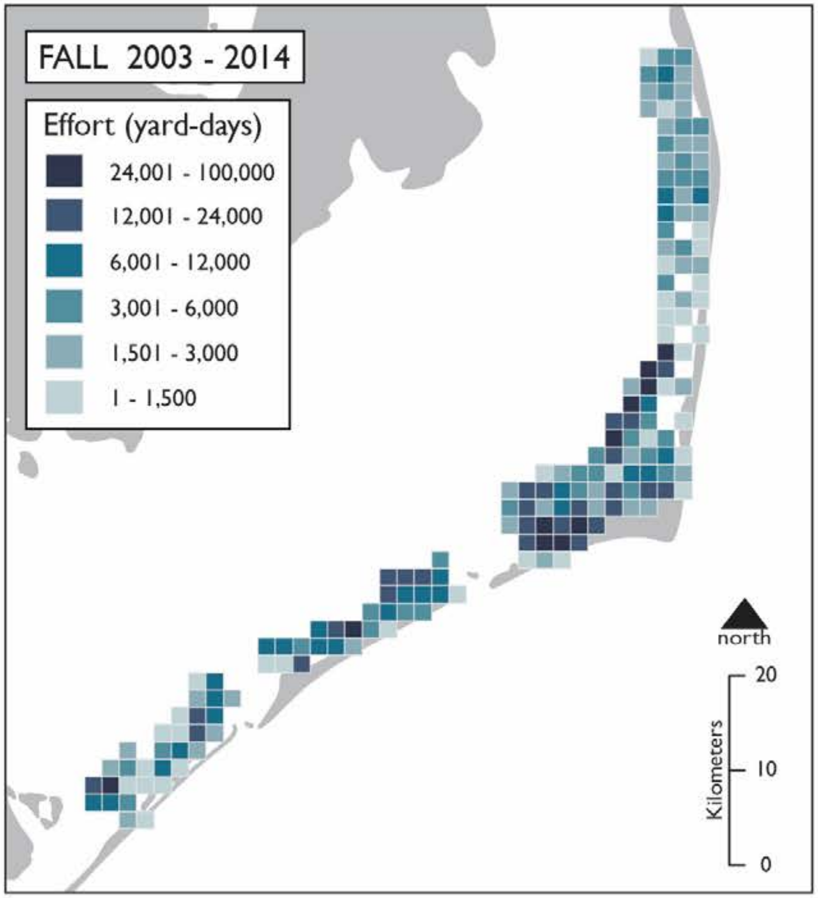


Figure 5. Fishing effort in Program 466 summed up across all records located within each grid cell during fall (September - December) between 2003 - 2014. Effort is calculated as the product of net length (yards) and the amount of time gear was fished (days) at each location.

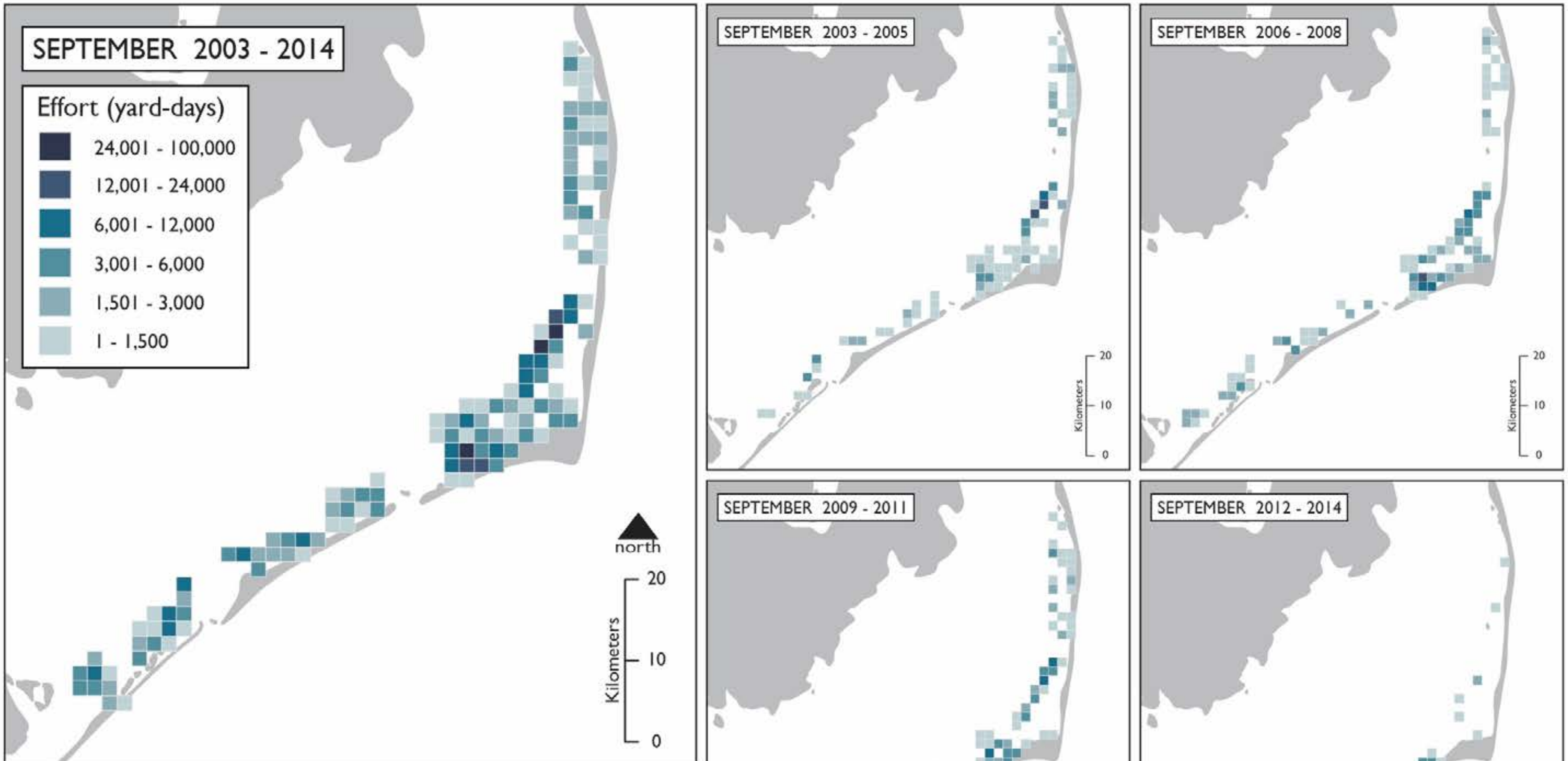


Figure 6. Fishing effort in Program 466 summed up across all records located within each grid cell during September between 2003 - 2014. Effort is calculated as the product of net length (yards) and the amount of time gear was fished (days) at each location.

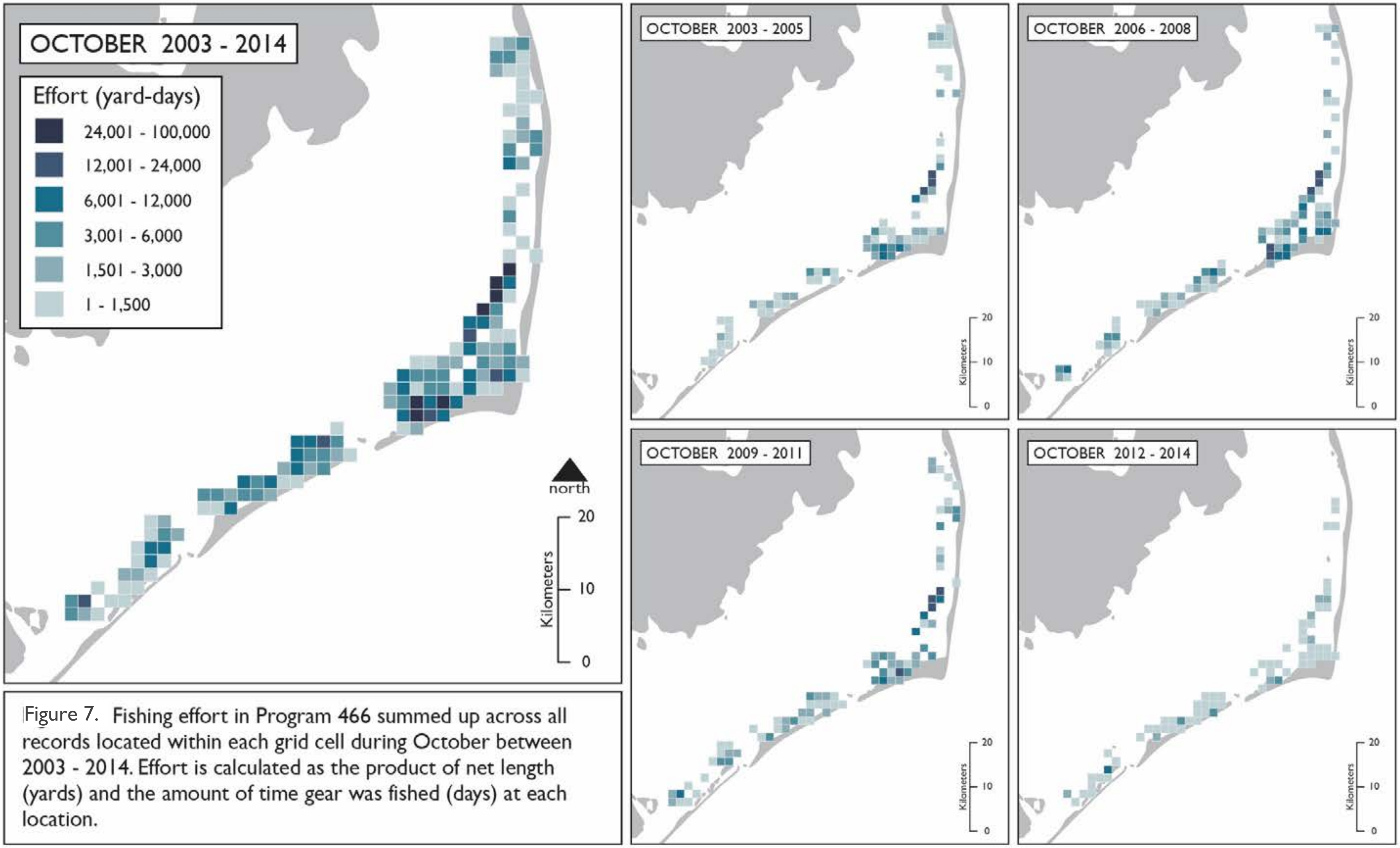


Figure 7. Fishing effort in Program 466 summed up across all records located within each grid cell during October between 2003 - 2014. Effort is calculated as the product of net length (yards) and the amount of time gear was fished (days) at each location.

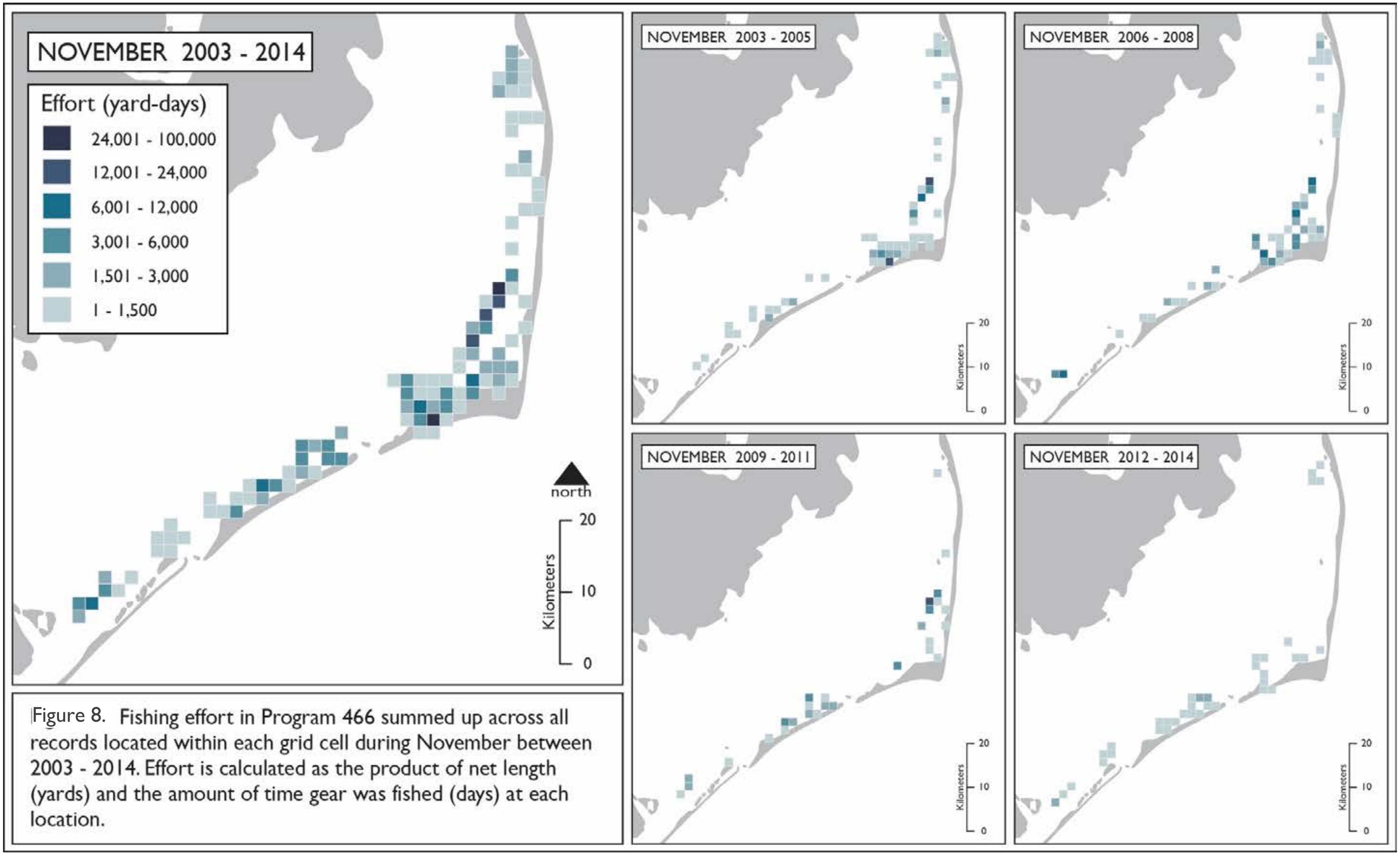


Figure 8. Fishing effort in Program 466 summed up across all records located within each grid cell during November between 2003 - 2014. Effort is calculated as the product of net length (yards) and the amount of time gear was fished (days) at each location.

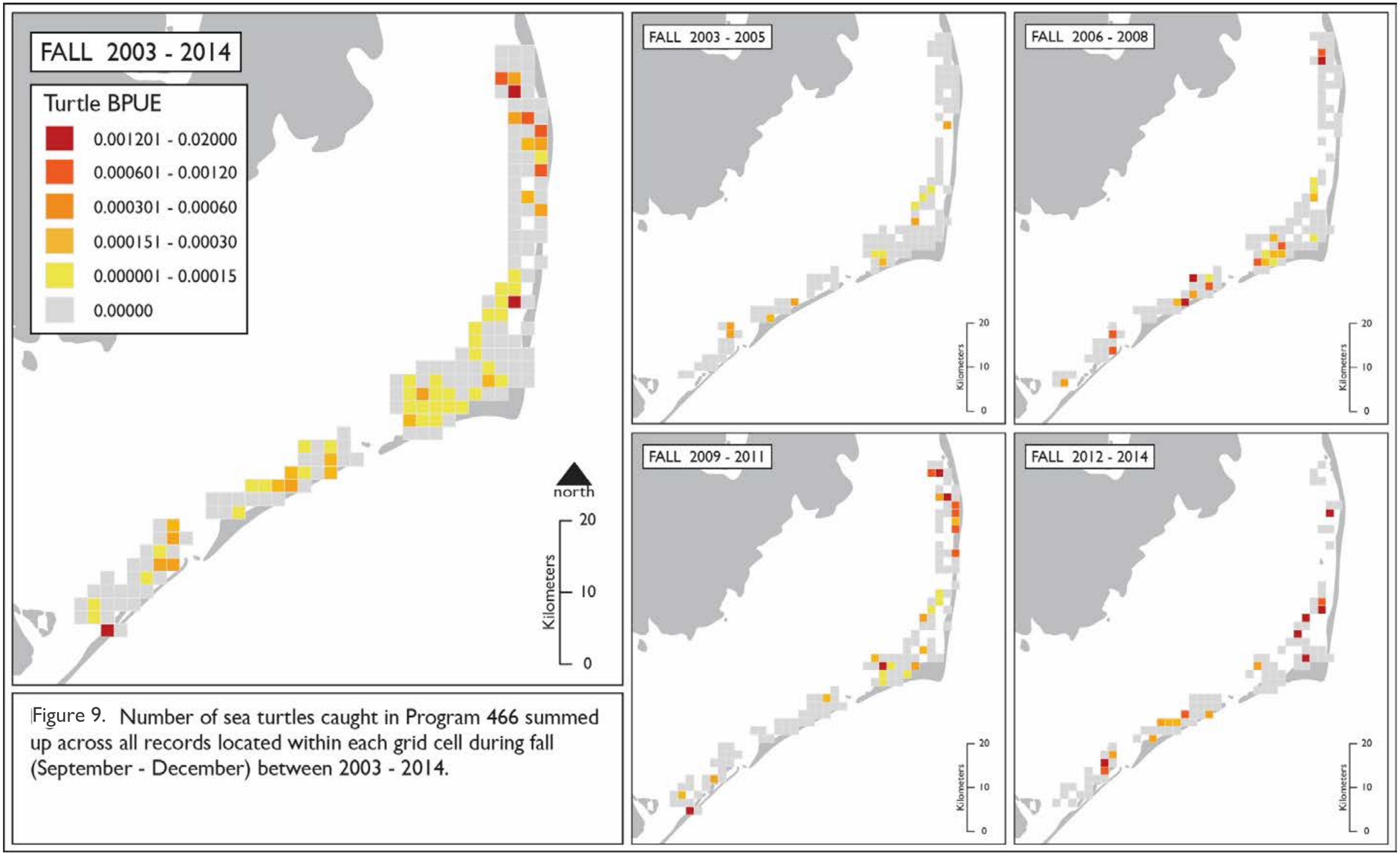


Figure 9. Number of sea turtles caught in Program 466 summed up across all records located within each grid cell during fall (September - December) between 2003 - 2014.

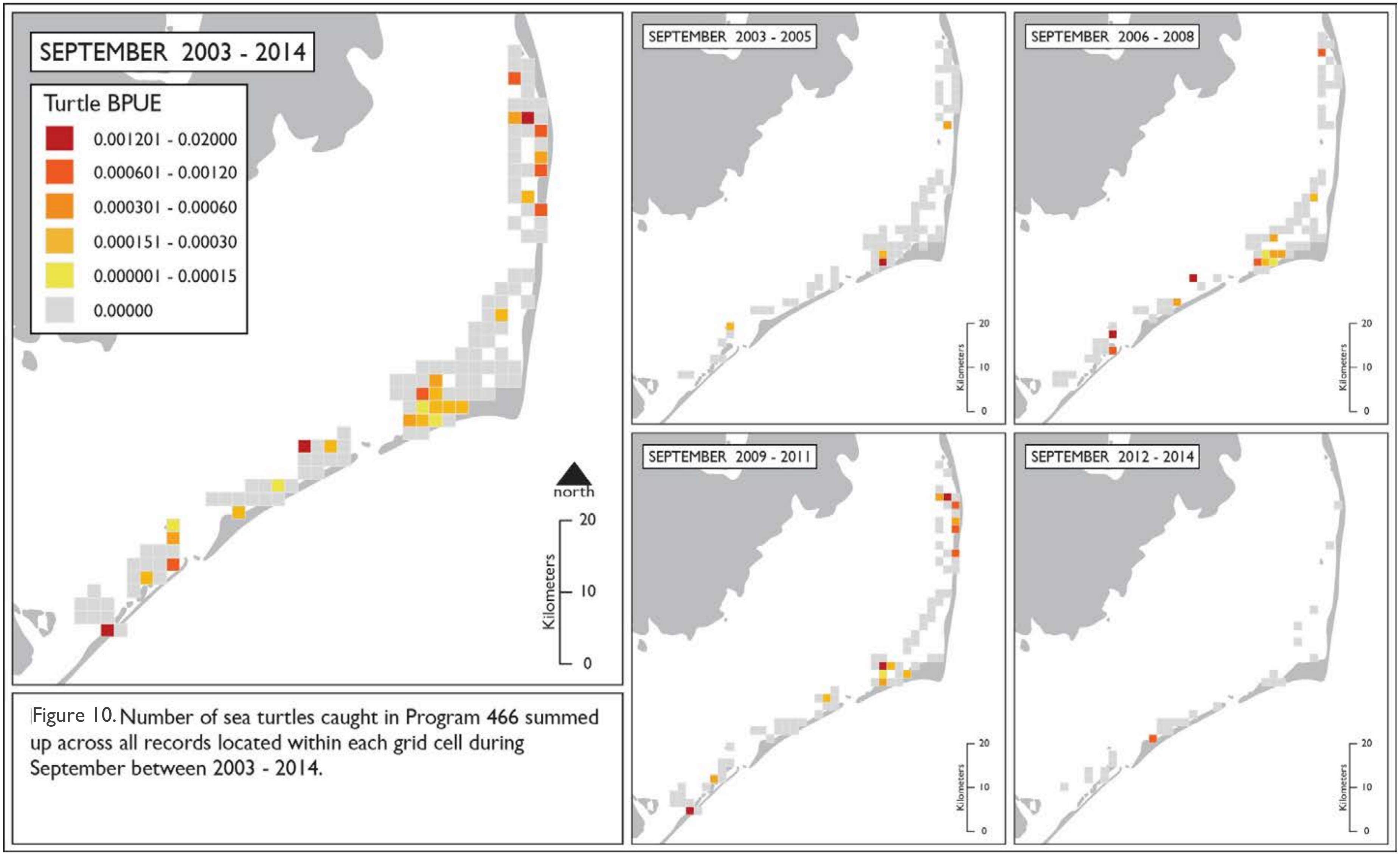


Figure 10. Number of sea turtles caught in Program 466 summed up across all records located within each grid cell during September between 2003 - 2014.

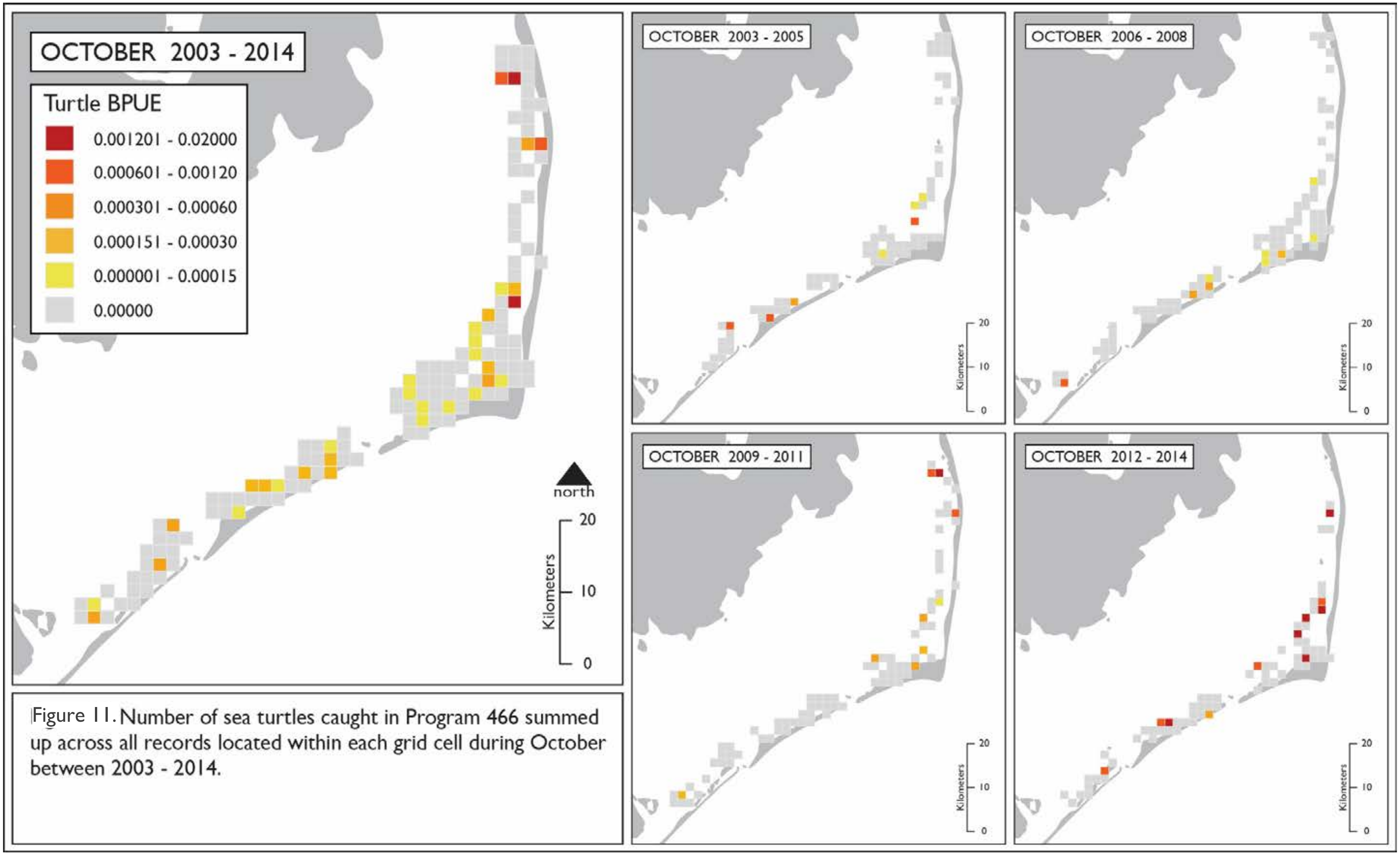


Figure 11. Number of sea turtles caught in Program 466 summed up across all records located within each grid cell during October between 2003 - 2014.

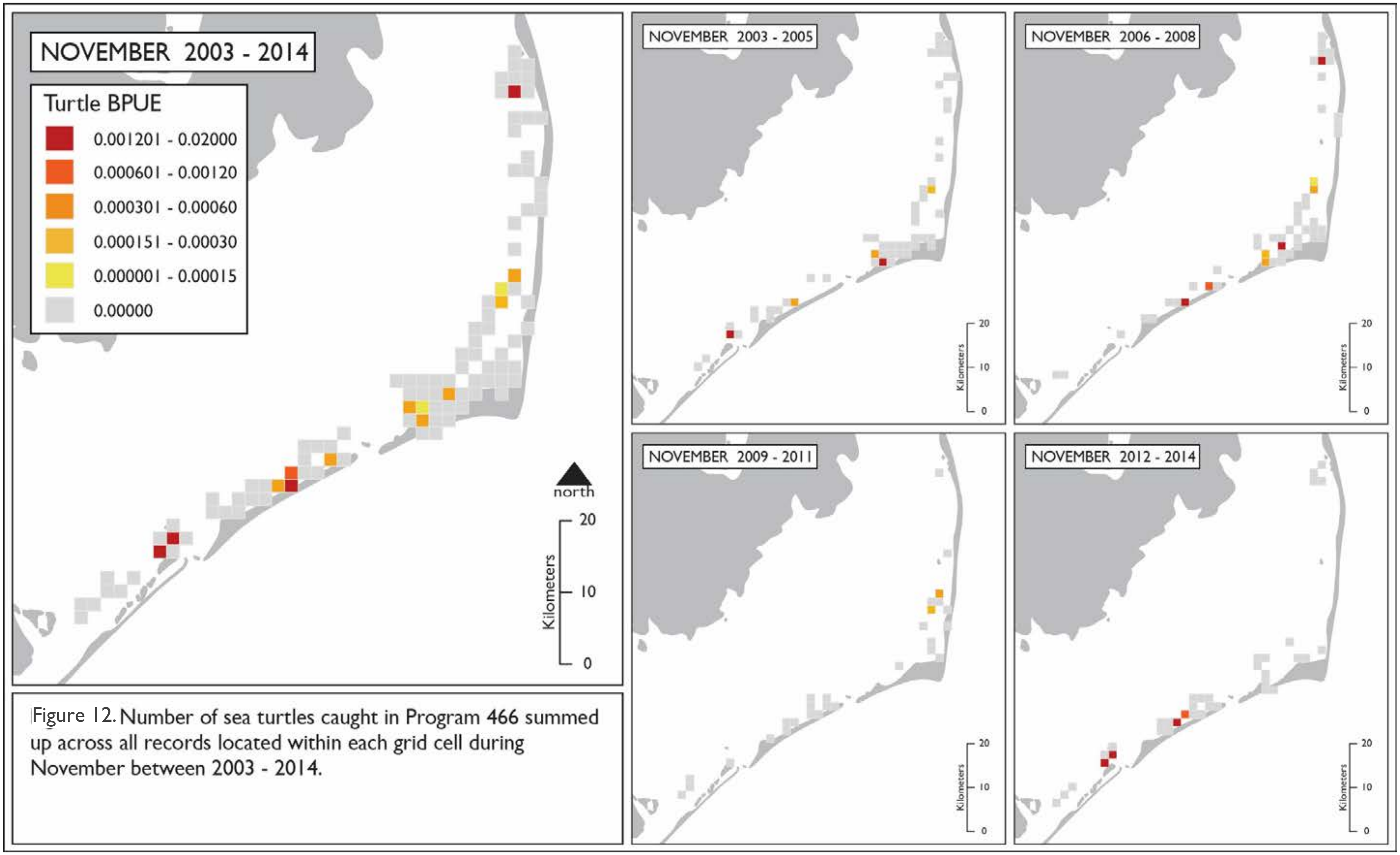


Figure 12. Number of sea turtles caught in Program 466 summed up across all records located within each grid cell during November between 2003 - 2014.

Figure 13. Sea turtle bycatch, fishing effort, and bycatch per unit effort recorded by DMF Program 466 observers during fall (September to December) 2003 - 2014.

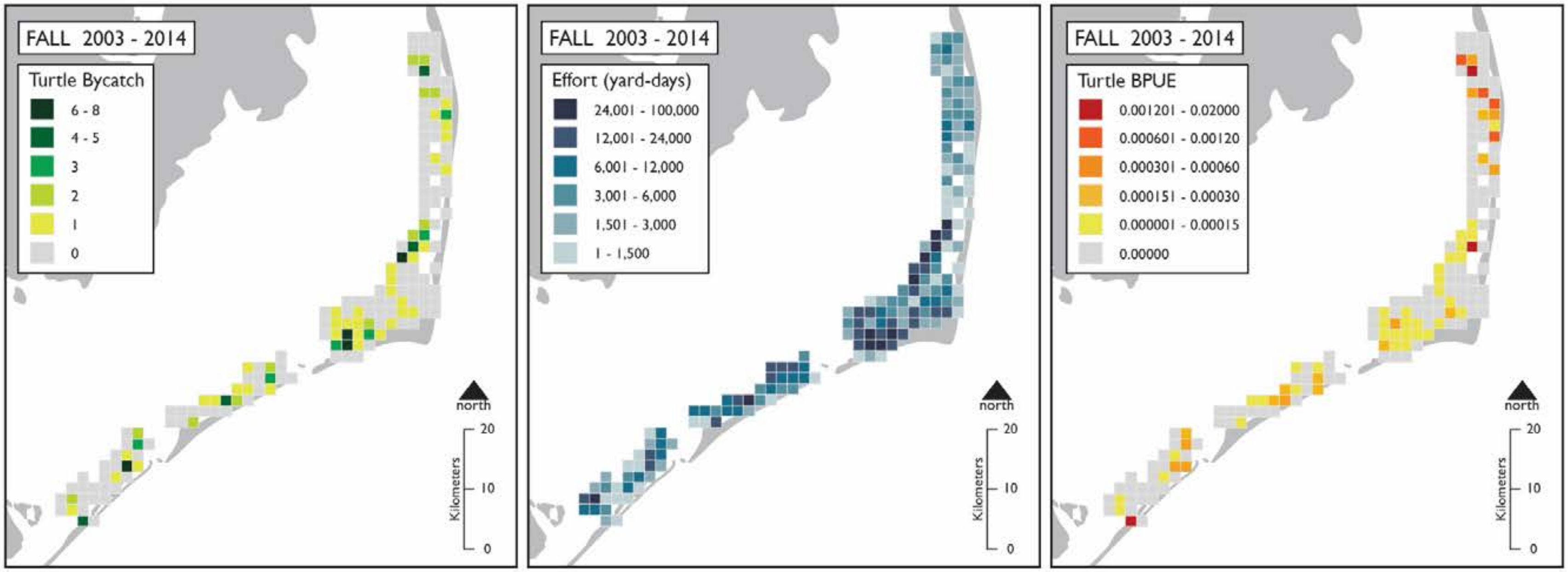


Figure 14. Sea turtle bycatch, fishing effort, and bycatch per unit effort recorded by DMF Program 466 observers during fall (September - December) 2003 - 2005.

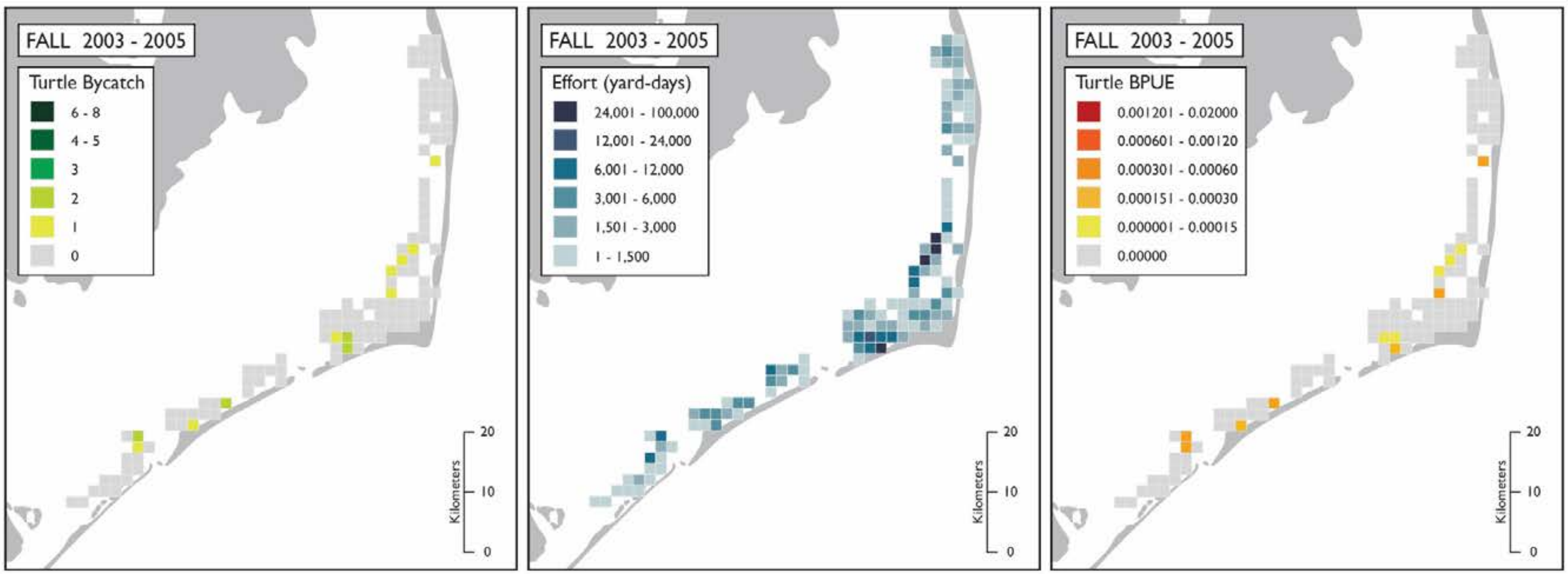


Figure 15. Sea turtle bycatch, fishing effort, and bycatch per unit effort recorded by DMF Program 466 observers during fall (September to December) 2003 - 2014.

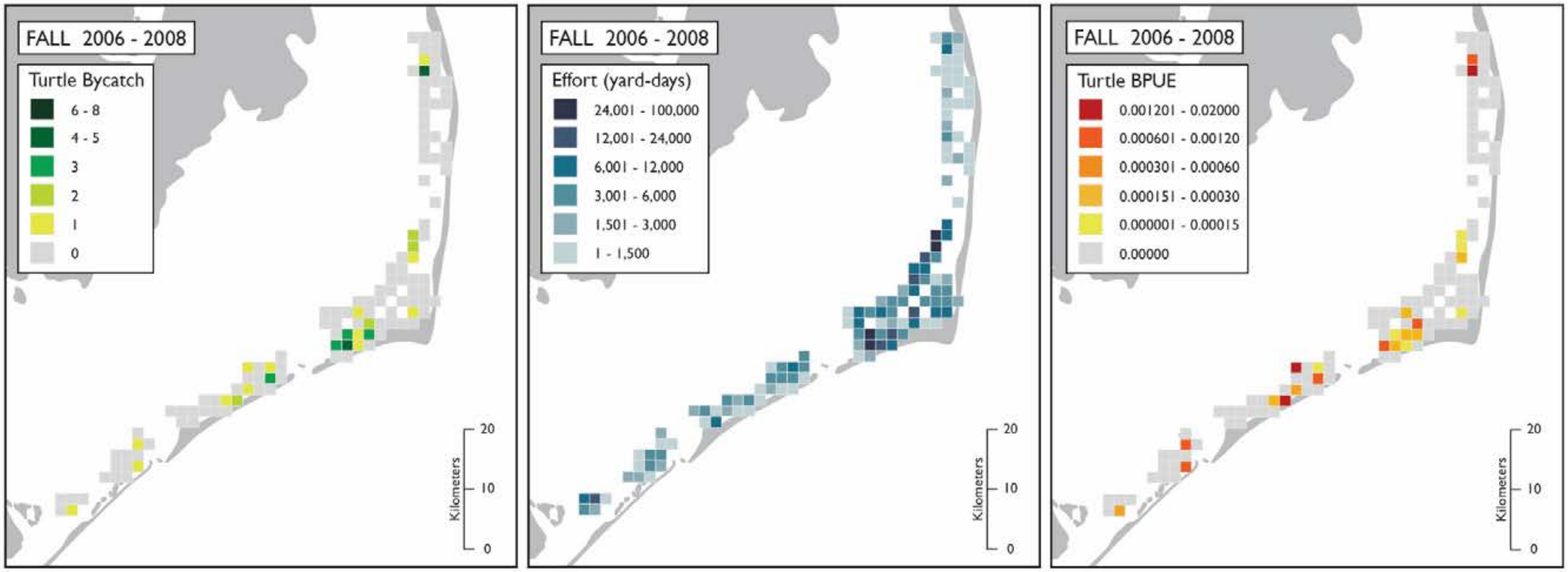
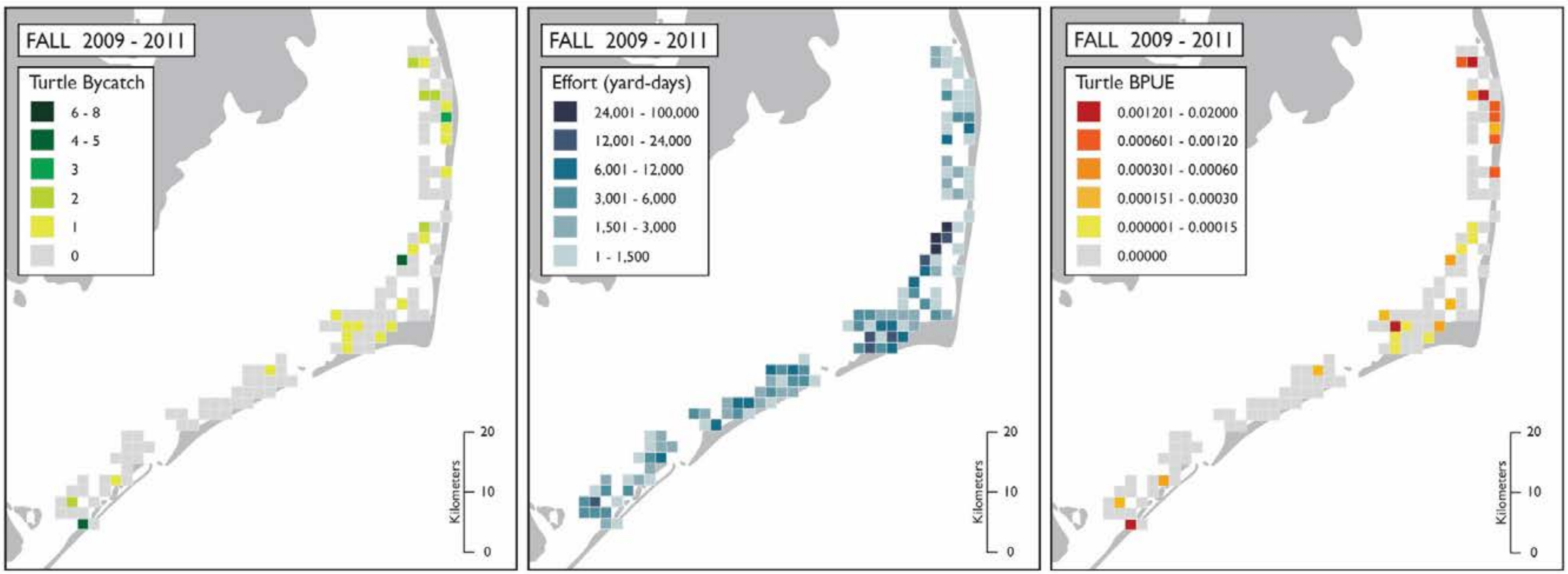


Figure 16. Sea turtle bycatch, fishing effort, and bycatch per unit effort recorded by DMF Program 466 observers during fall (September - December) 2003 - 2005.



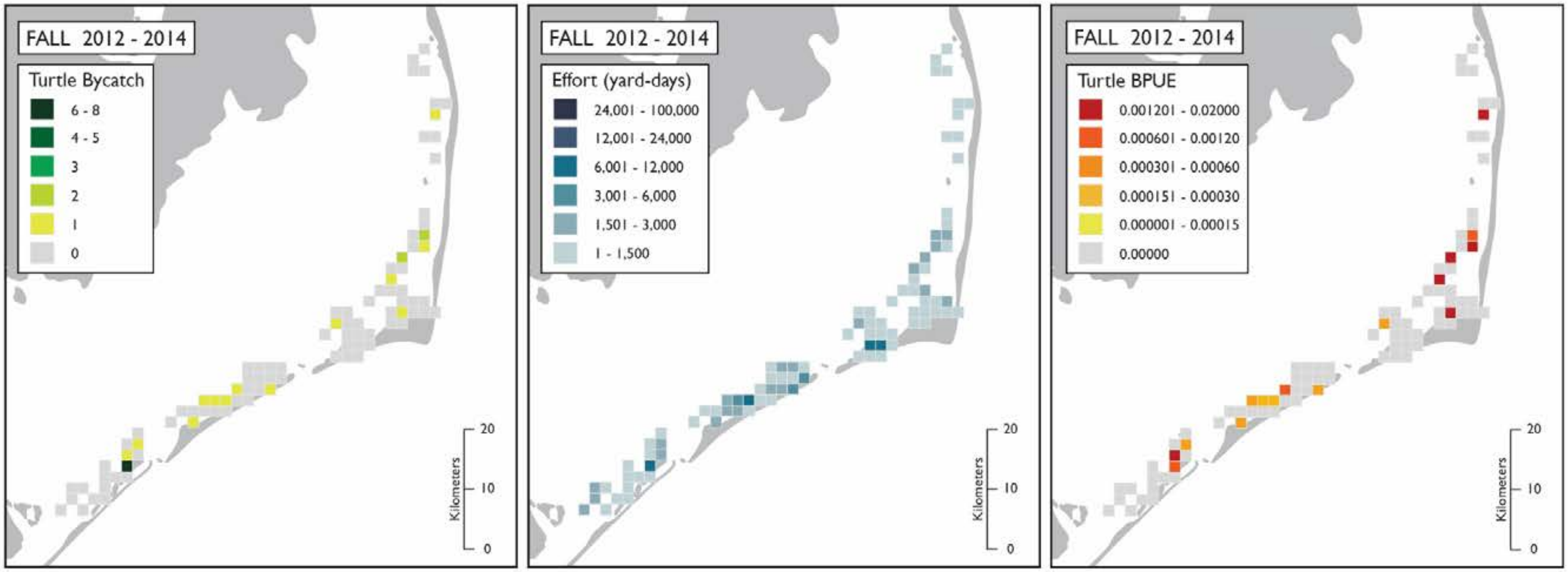


Figure 17. Sea turtle bycatch, fishing effort, and bycatch per unit effort recorded by DMF Program 466 observers during fall (September to December) 2003 - 2014.

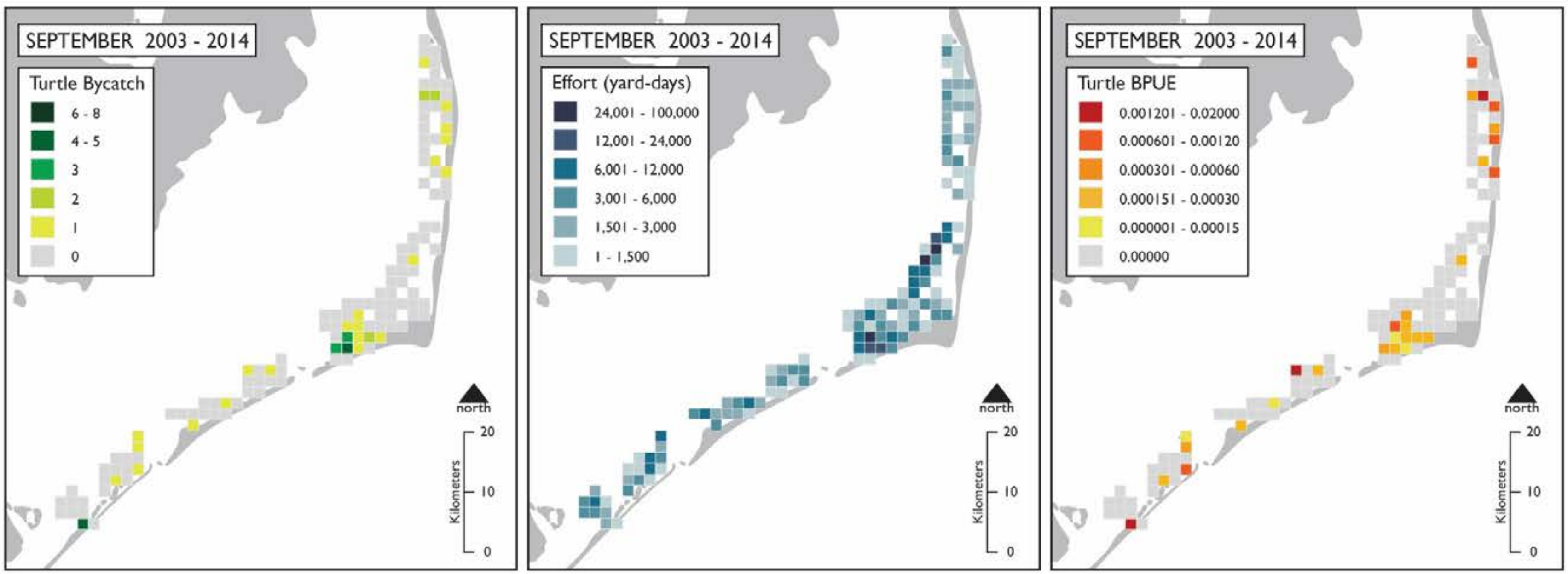


Figure 18. Sea turtle bycatch, fishing effort, and bycatch per unit effort recorded by DMF Program 466 observers during fall (September - December) 2003 - 2005.

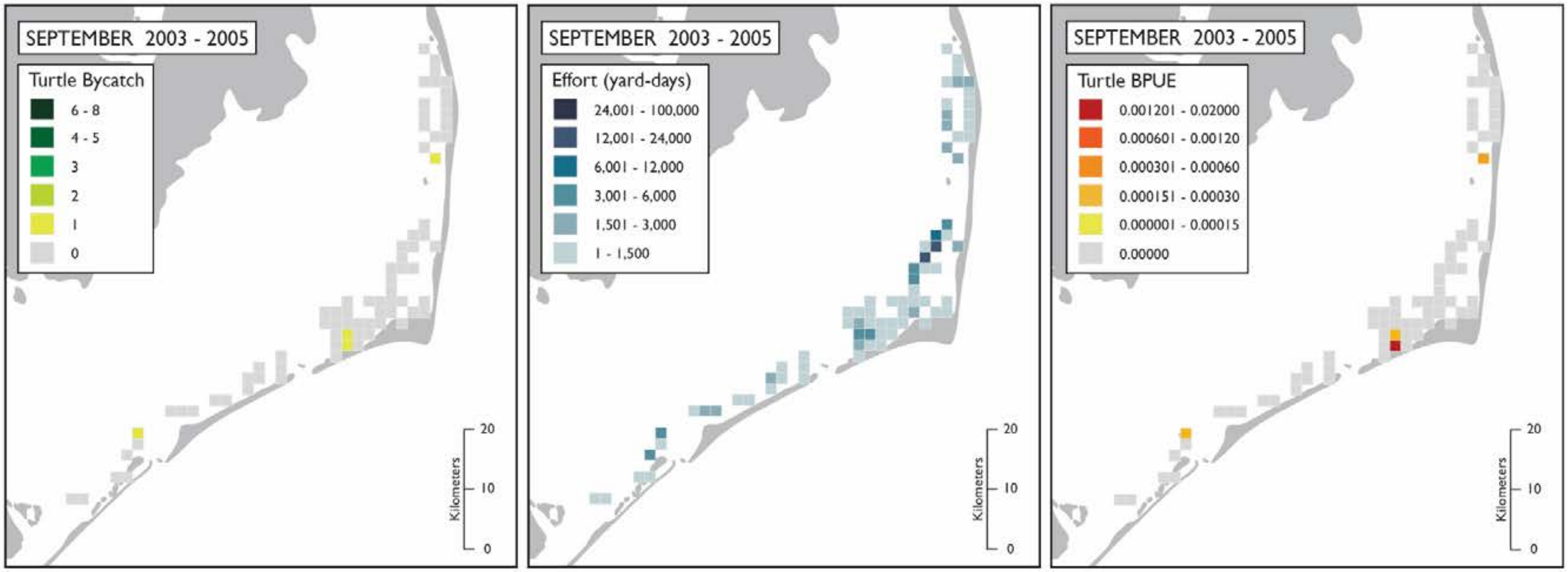


Figure 19. Sea turtle bycatch, fishing effort, and bycatch per unit effort recorded by DMF Program 466 observers during fall (September to December) 2003 - 2014.

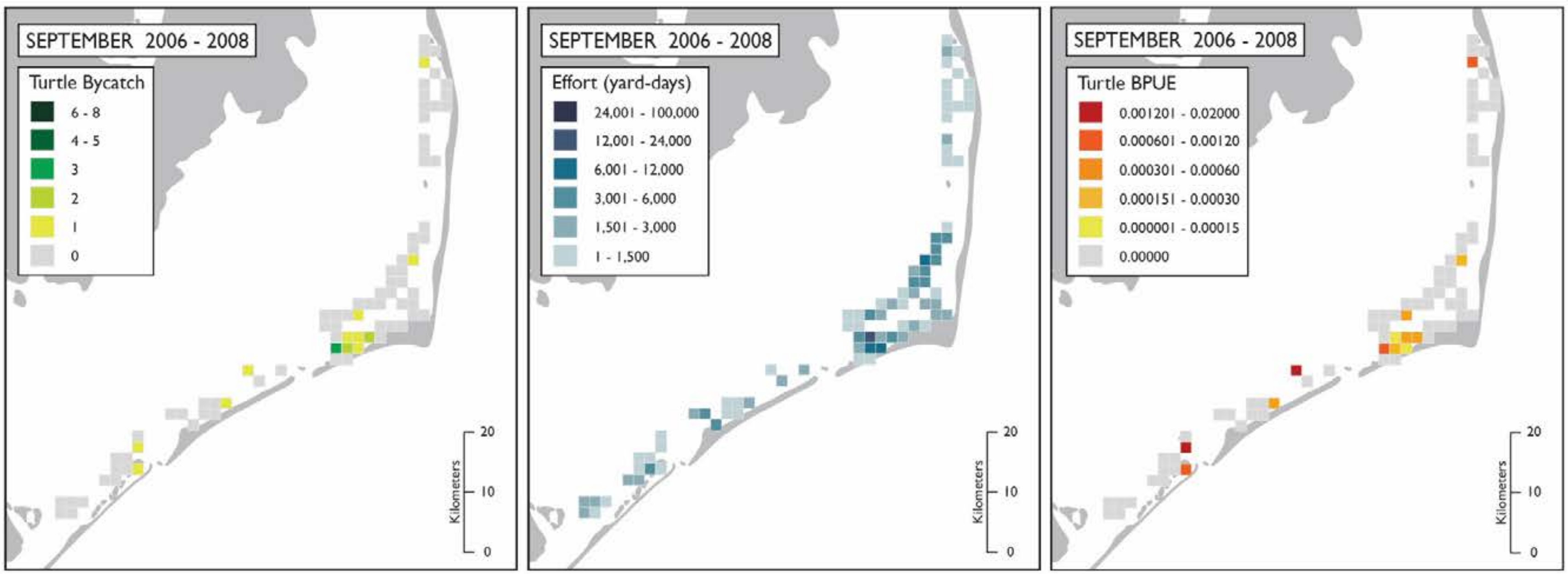


Figure 20. Sea turtle bycatch, fishing effort, and bycatch per unit effort recorded by DMF Program 466 observers during fall (September - December) 2003 - 2005.

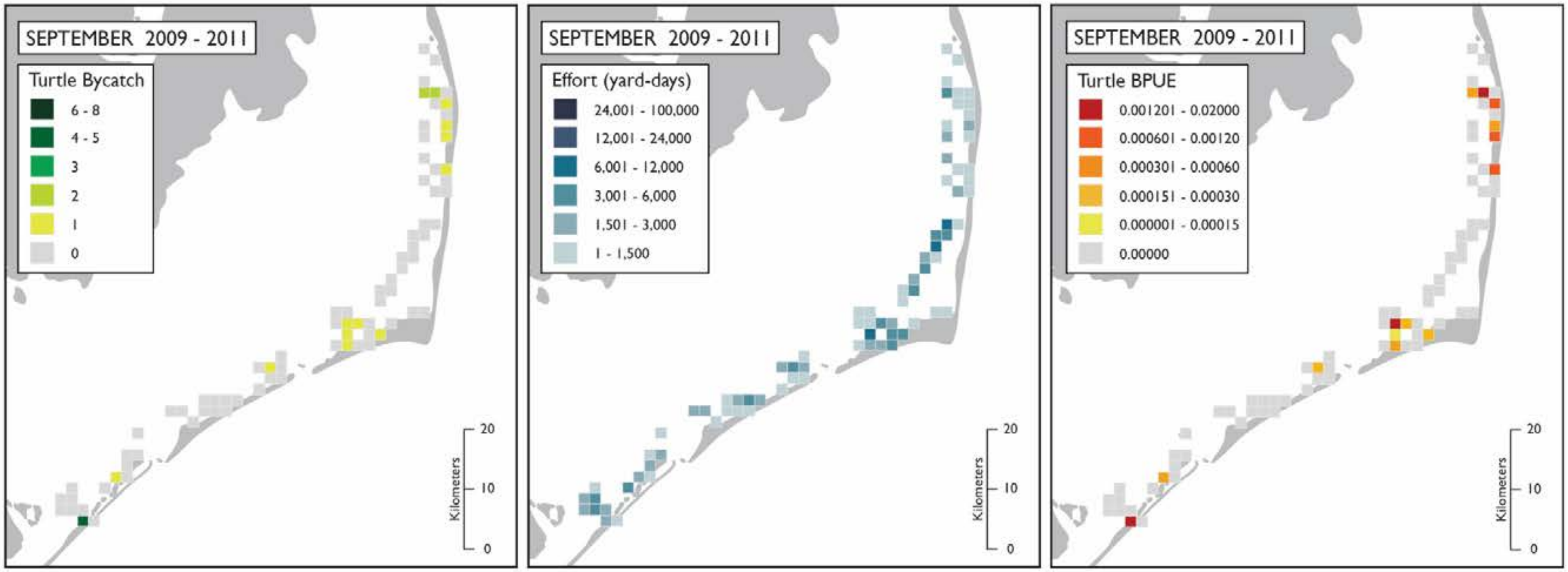


Figure 21. Sea turtle bycatch, fishing effort, and bycatch per unit effort recorded by DMF Program 466 observers during fall (September to December) 2003 - 2014.

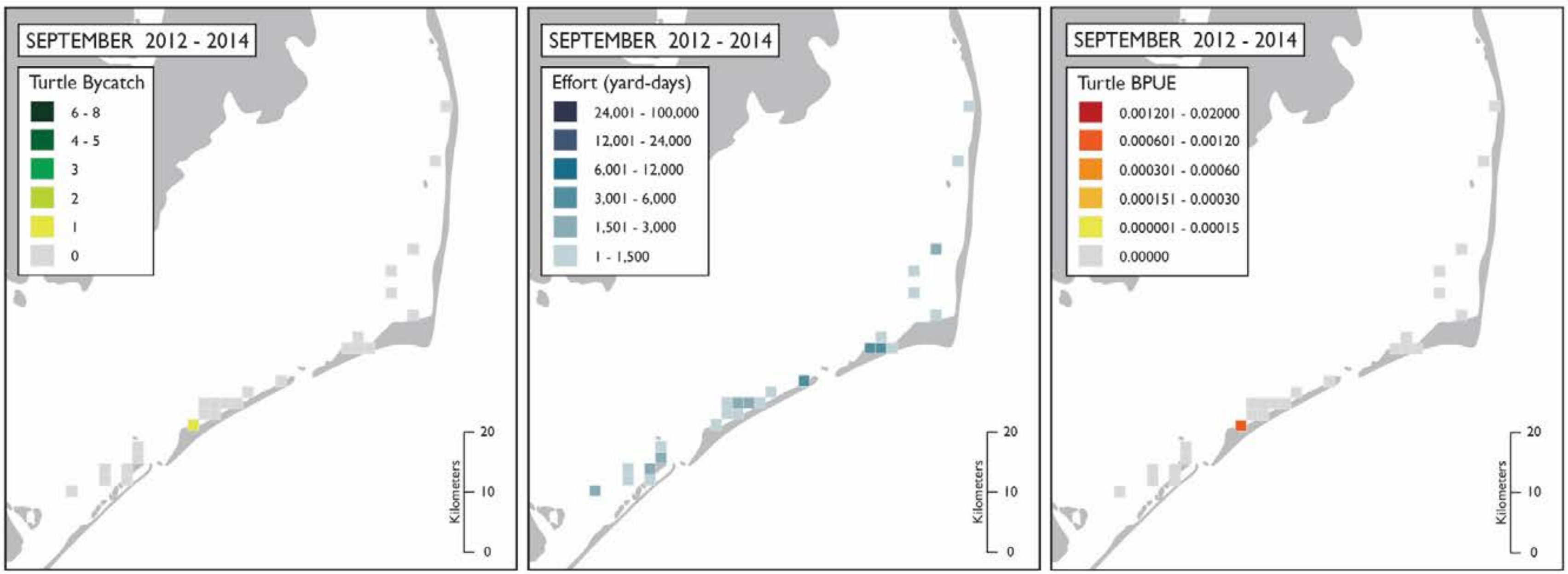


Figure 22. Sea turtle bycatch, fishing effort, and bycatch per unit effort recorded by DMF Program 466 observers during fall (September - December) 2003 - 2005.

Figure 23. Sea turtle bycatch, fishing effort, and bycatch per unit effort recorded by DMF Program 466 observers during fall (September to December) 2003 - 2014.

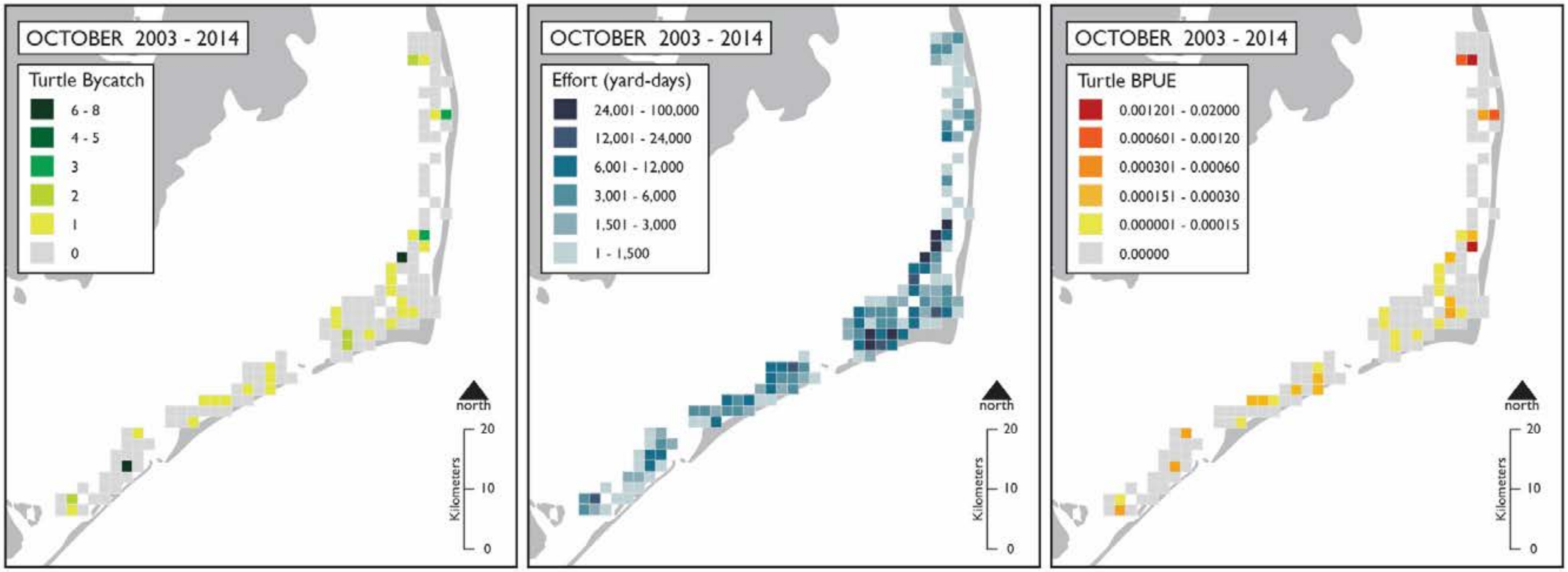


Figure 24. Sea turtle bycatch, fishing effort, and bycatch per unit effort recorded by DMF Program 466 observers during fall (September - December) 2003 - 2005.

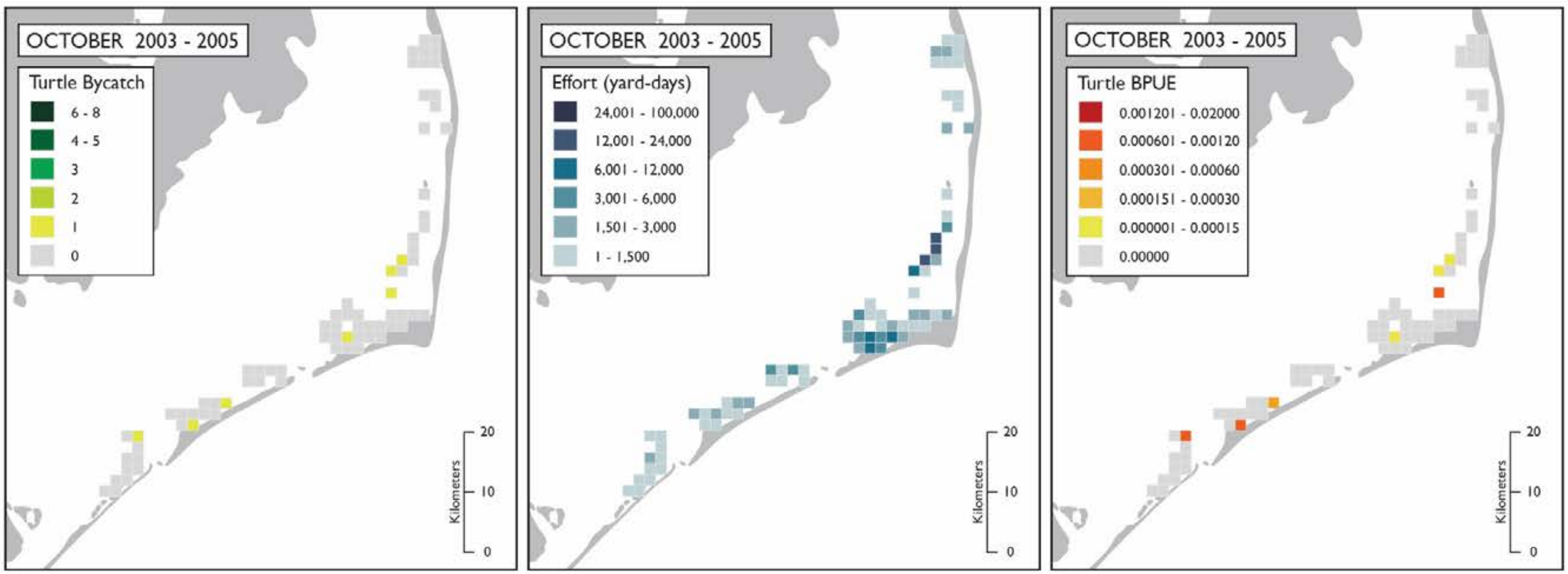


Figure 25. Sea turtle bycatch, fishing effort, and bycatch per unit effort recorded by DMF Program 466 observers during fall (September to December) 2003 - 2014.

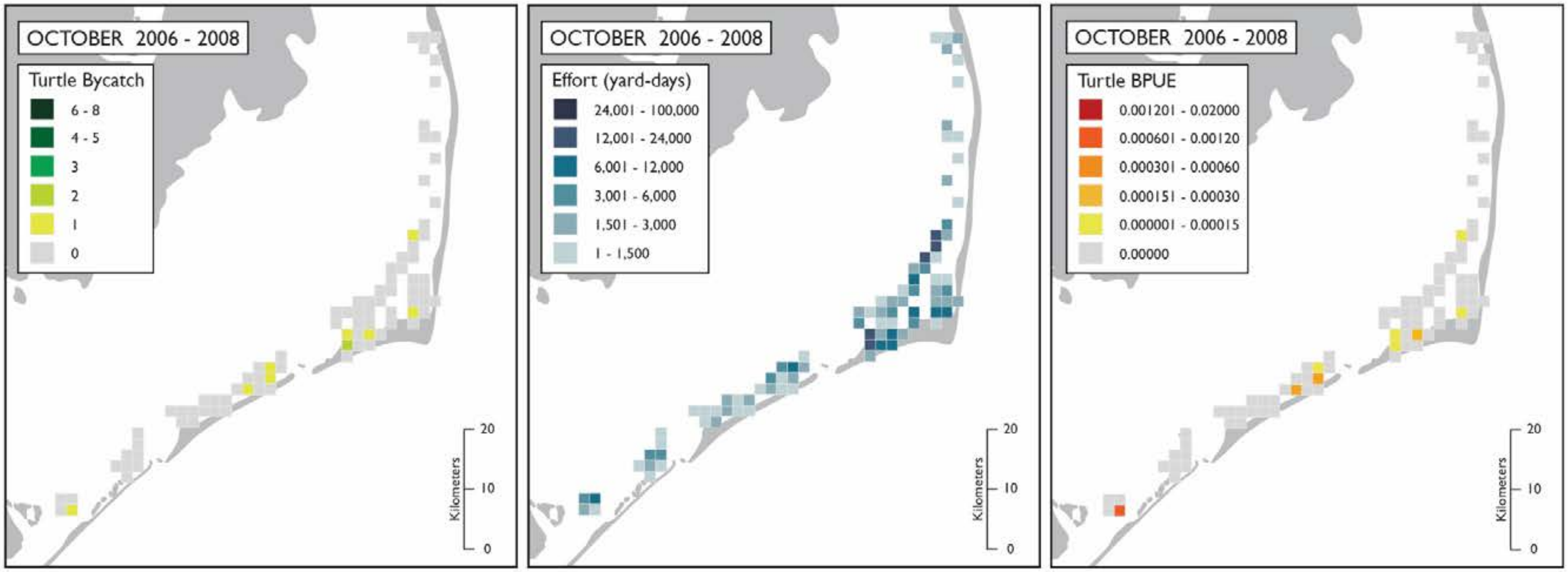


Figure 26. Sea turtle bycatch, fishing effort, and bycatch per unit effort recorded by DMF Program 466 observers during fall (September - December) 2003 - 2005.

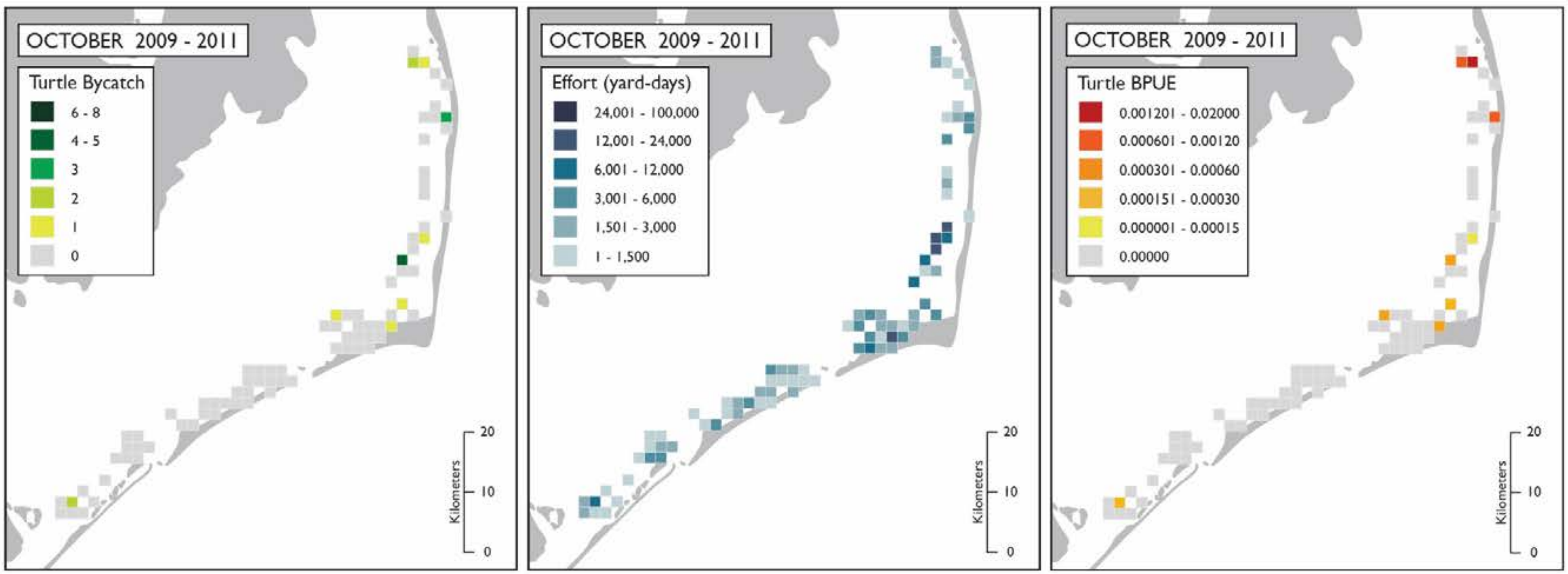


Figure 27. Sea turtle bycatch, fishing effort, and bycatch per unit effort recorded by DMF Program 466 observers during fall (September to December) 2003 - 2014.

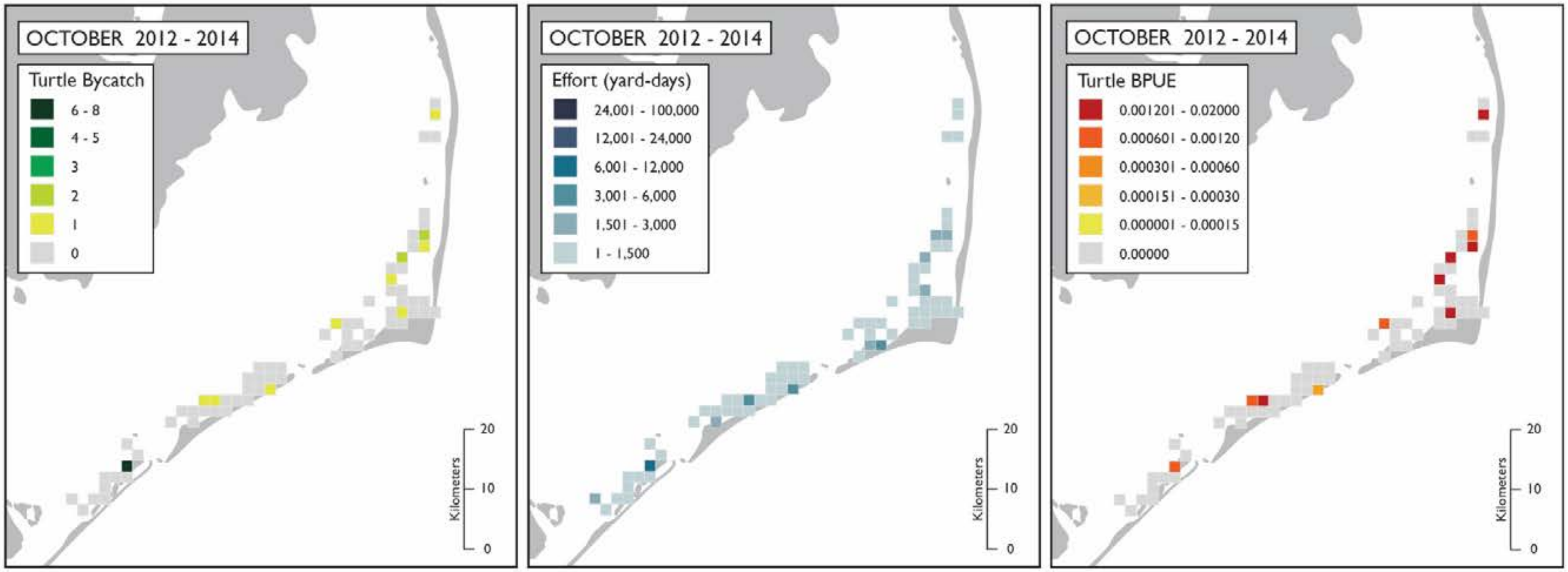
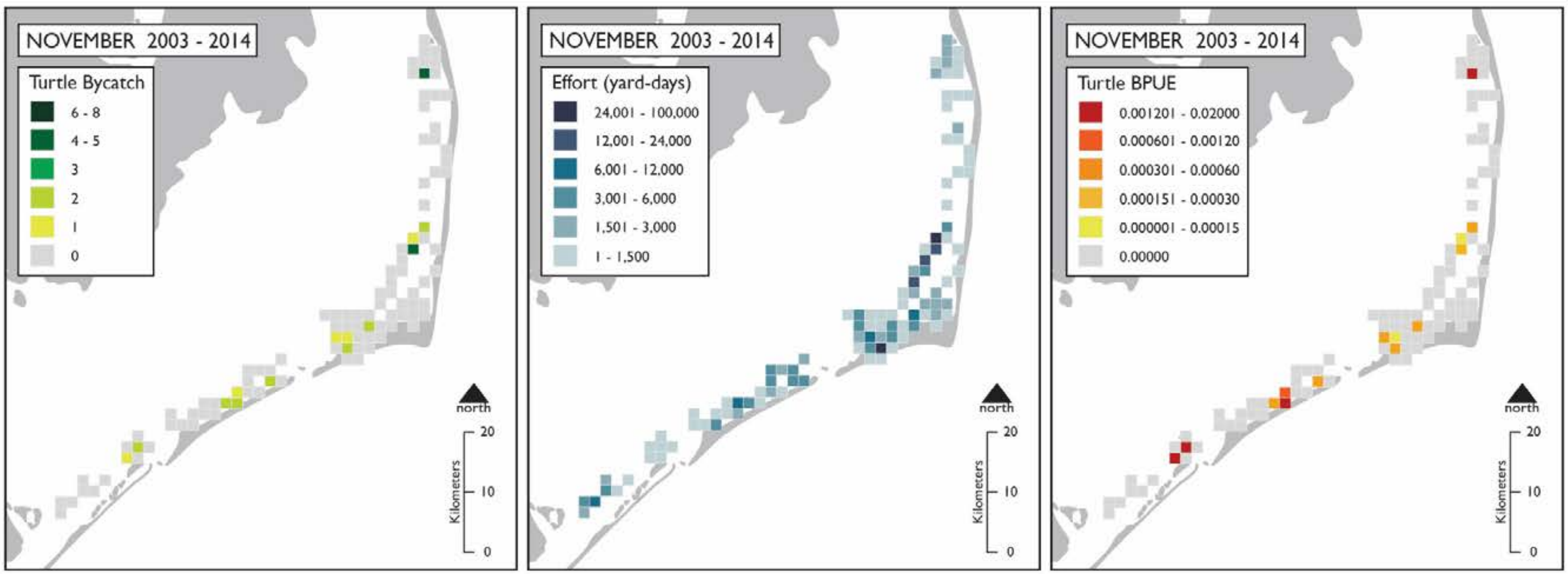


Figure 28. Sea turtle bycatch, fishing effort, and bycatch per unit effort recorded by DMF Program 466 observers during fall (September - December) 2003 - 2005.



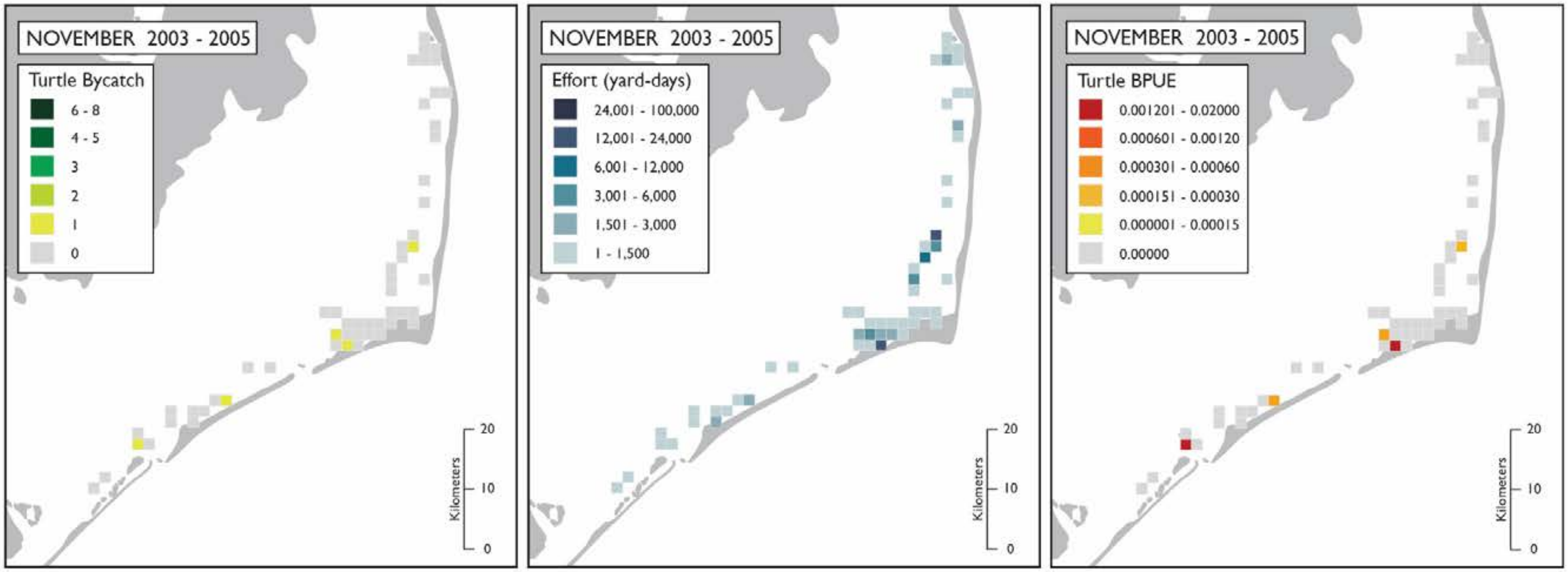


Figure 29. Sea turtle bycatch, fishing effort, and bycatch per unit effort recorded by DMF Program 466 observers during fall (September to December) 2003 - 2014.

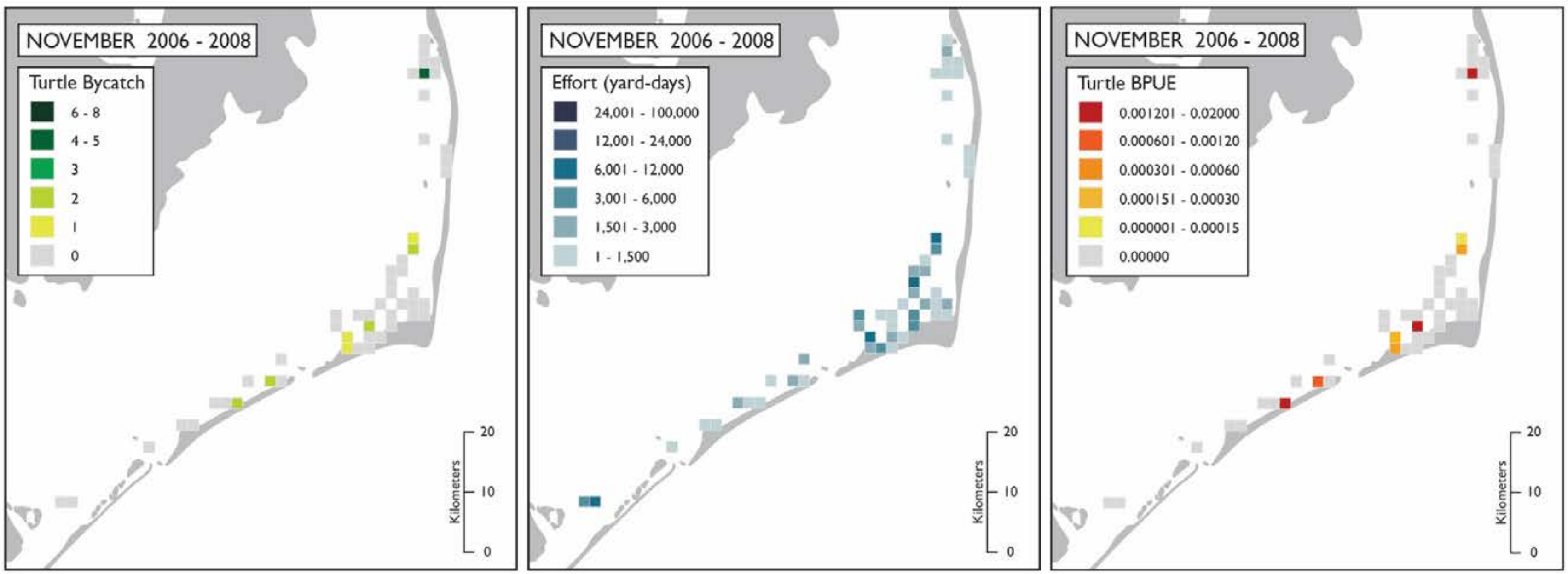


Figure 30. Sea turtle bycatch, fishing effort, and bycatch per unit effort recorded by DMF Program 466 observers during fall (September - December) 2003 - 2005.

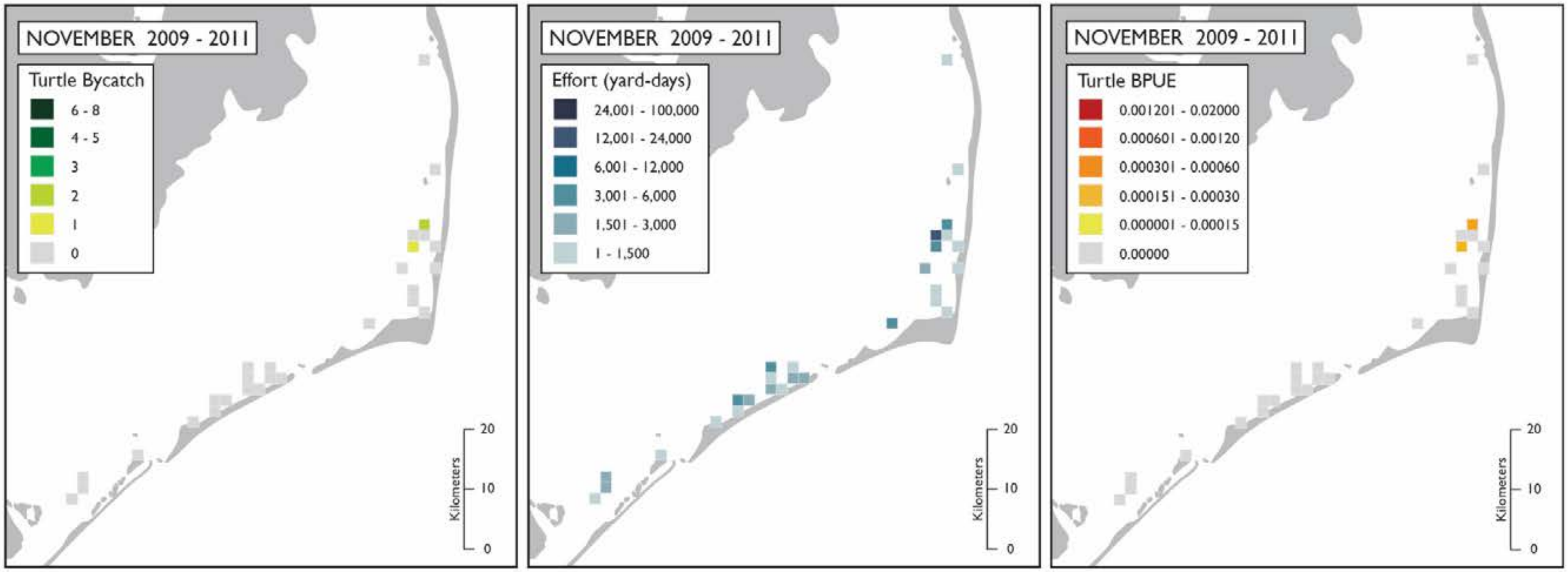


Figure 31. Sea turtle bycatch, fishing effort, and bycatch per unit effort recorded by DMF Program 466 observers during fall (September to December) 2003 - 2014.

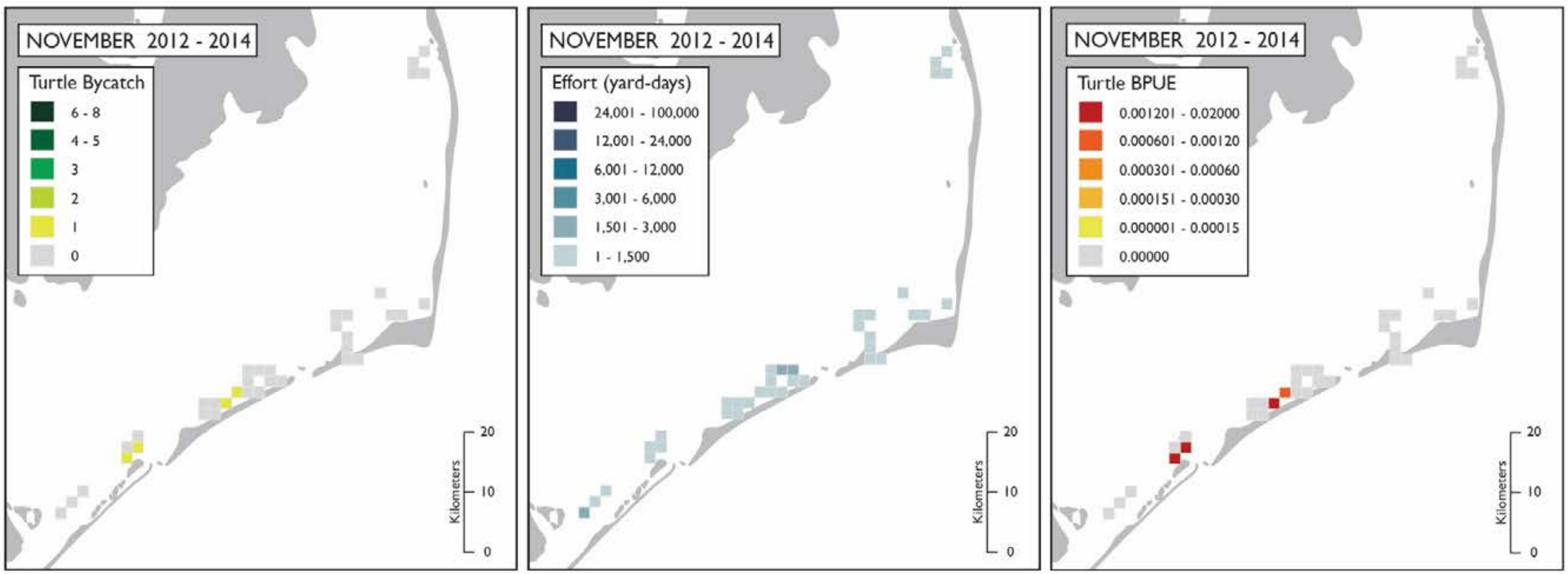


Figure 32. Sea turtle bycatch, fishing effort, and bycatch per unit effort recorded by DMF Program 466 observers during fall (September - December) 2003 - 2005.

Table 1. Corridor expansion scenario names, geographic markers, and coordinates.

Corridor	Scenario Name	Geographic Marker	Latitude	Longitude
Oregon Inlet Corridor	Oreg_Green	Green Point	35.597	-75.472
	Oreg_Great	Great Island	35.531	-75.482
	Oreg_Clarks	Clark's Bay	35.531	-75.482
Hatteras Corridor	Hatt_Durant	Durant Point	35.233	-75.681
	Hatt_JoeSaur	Joe Saur Creek	35.229	-75.639
	Hatt_Brooks	Brooks Point	35.269	-75.596
Ocracoke Corridor	Ocra_Portsmouth	Portsmouth Island/Evergreen Slough	35.069	-76.076
	Ocra_Royal	Royal Point	35.053	-76.088

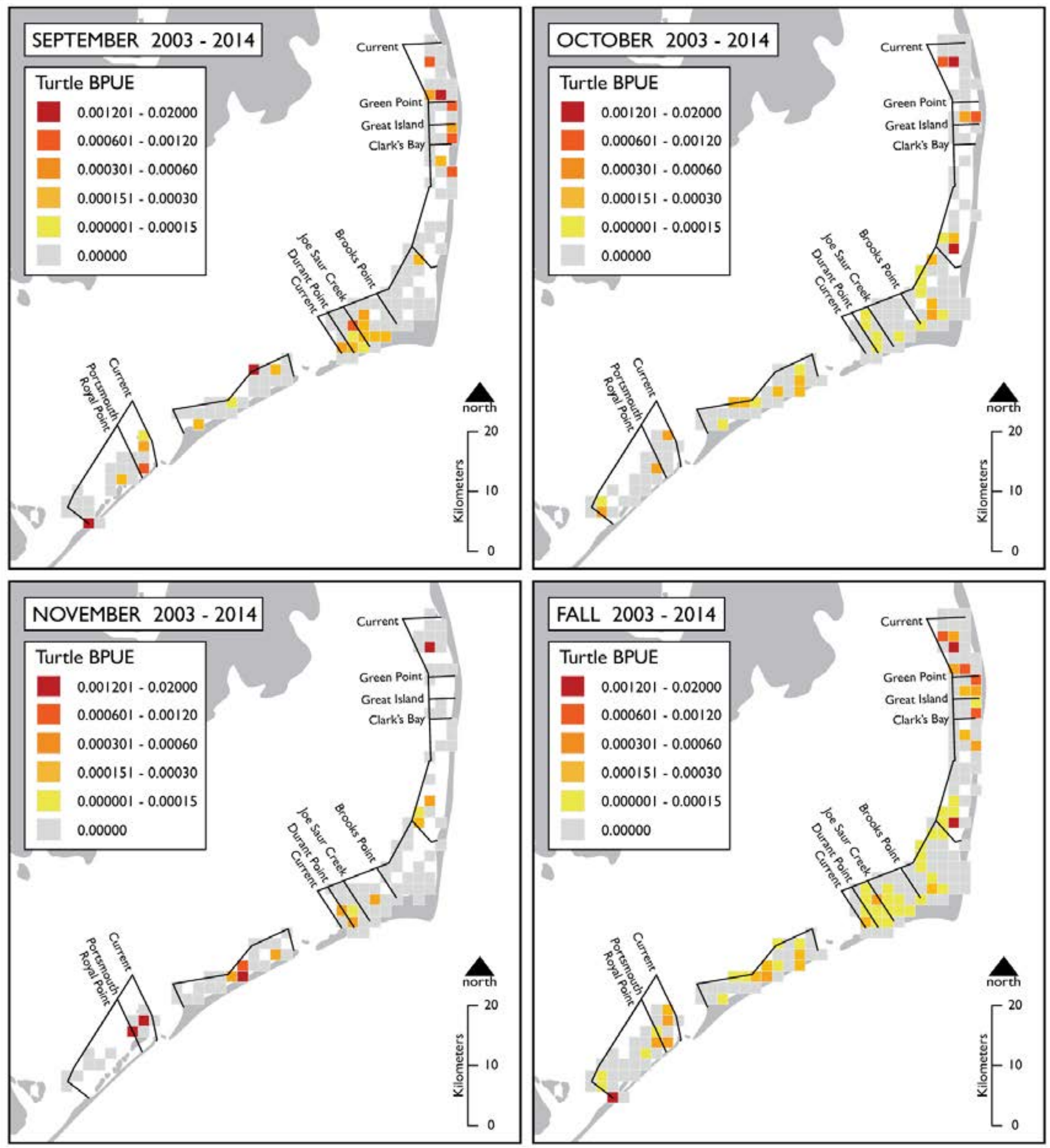


Figure 33. Proposed boundaries of expanded inlet corridors into Pamlico Sound overlaid on top of sea turtle catch per unit effort.

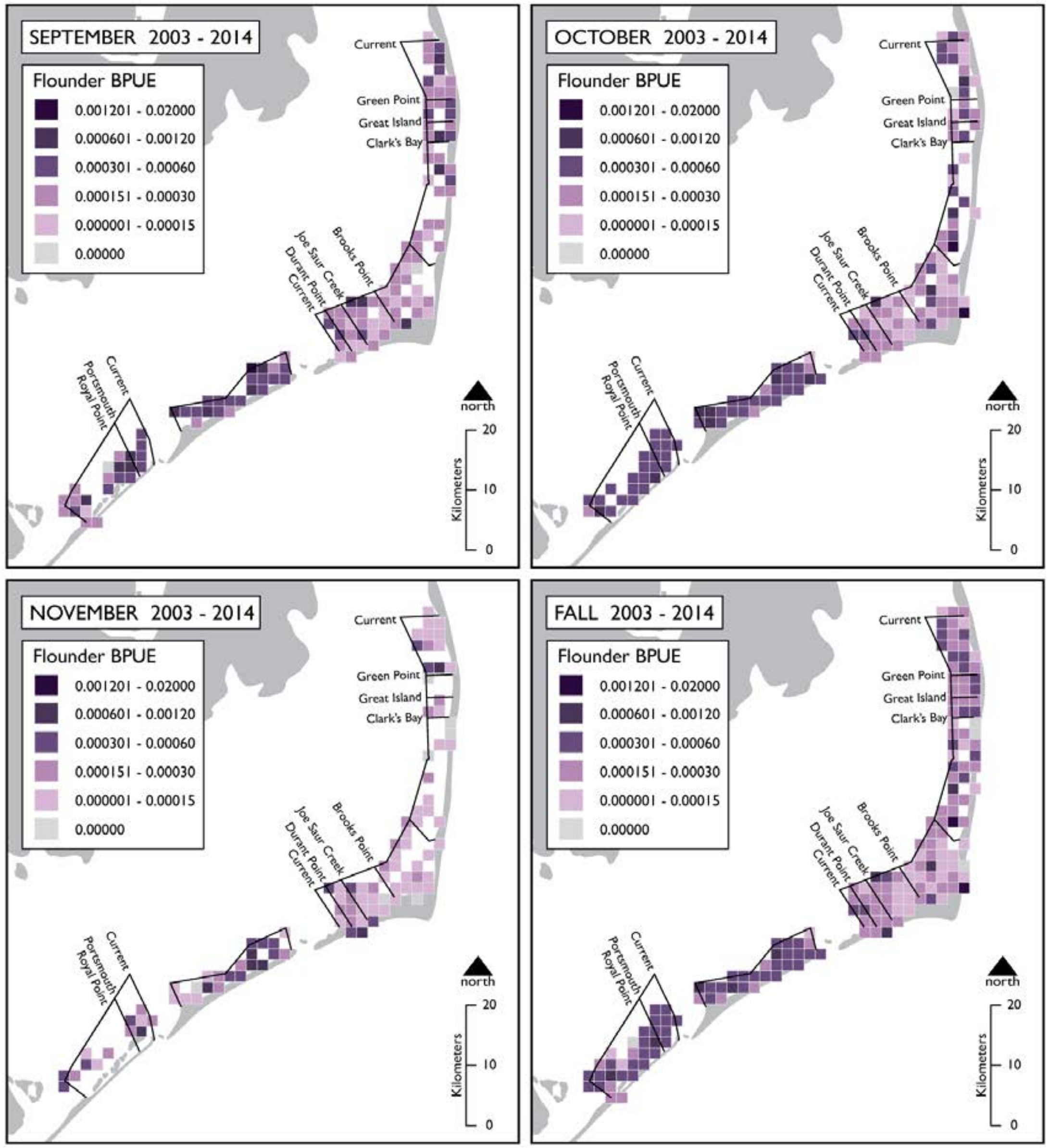


Figure 34. Proposed boundaries of expanded inlet corridors into Pamlico Sound overlaid on top of southern flounder catch per unit effort.

Table 2. Predicted number of sea turtles caught during fall from 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

FALL - SEA TURTLES	Corridor Expansion Scenarios	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
		No corridor expansion (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed based on previous distribution of effort	Effort redistributed based on distance to closed area boundary
	Oreg_Green	121	109	116	113	119
	Oreg_Great	121	104	112	108	108
	Oreg_Clarks	121	102	113	108	106
	Hatt_Durant	121	116	120	118	123
	Hatt_JoeSaur	121	99	127	114	131
	Hatt_Brooks	121	90	132	110	141
	Ocra_Portsmouth	121	113	116	118	115
	Ocra_Royal	121	108	111	114	109

Table 3. Percent change in the predicted number of sea turtles caught during fall from 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

FALL - SEA TURTLES	Corridor Expansion Scenarios	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
		No corridor expansion (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed based on previous distribution of effort	Effort redistributed based on distance to closed area boundary
	Oreg_Green	0%	-9.9%	-4.1%	-6.6%	-1.7%
	Oreg_Great	0%	-14.0%	-7.4%	-10.7%	-10.7%
	Oreg_Clarks	0%	-15.7%	-6.6%	-10.7%	-12.4%
	Hatt_Durant	0%	-4.1%	-0.8%	-2.5%	1.7%
	Hatt_JoeSaur	0%	-18.2%	5.0%	-5.8%	8.3%
	Hatt_Brooks	0%	-25.6%	9.1%	-9.1%	16.5%
	Ocra_Portsmouth	0%	-6.6%	-4.1%	-2.5%	-5.0%
	Ocra_Royal	0%	-10.7%	-8.3%	-5.8%	-9.9%

Table 4. Analysis of the efficiency of different corridor expansion scenarios under effort redistribution scenarios #3 & #4 during fall between 2003 - 2014 in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

FALL - SEA TURTLES	Corridor Expansion Scenarios	Expansion Area (km^2)	Effort displaced (yard-days)	Reduction in the number of sea turtles caught		Ratio of sea turtles caught to area closed		Ratio of sea turtles caught to effort displaced		Ratio of sea turtles caught to change in flounder catch	
				Scenario 3	Scenario 4	Scenario 3	Scenario 4	Scenario 3	Scenario 4	Scenario 3	Scenario 4
	Oreg_Green	55	60425	8	2	0.15	0.04	0.00013	0.00003	0.07	0.08
	Oreg_Great	72	80837	13	13	0.18	0.18	0.00016	0.00016	0.08	0.12
	Oreg_Clarks	86	114651	13	15	0.15	0.17	0.00011	0.00013	0.04	0.01
	Hatt_Durant	13	40487	3	-2	0.22	-0.15	0.00007	-0.00005	0.00	0.00
	Hatt_JoeSaur	39	290730	7	-10	0.18	-0.26	0.00002	-0.00003	0.01	-0.05
	Hatt_Brooks	79	424954	11	-20	0.14	-0.25	0.00003	-0.00005	0.06	-0.04
	Ocra_Portsmouth	39	47210	3	6	0.08	0.15	0.00006	0.00013	0.13	0.01
	Ocra_Royal	53	71232	7	12	0.13	0.23	0.00010	0.00017	0.01	0.12

Table 5. Predicted number of flounder caught during fall from 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

FALL - FLOUNDER	Corridor Expansion Scenarios	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
		No corridor expansion (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed based on previous distribution of effort	Effort redistributed based on distance to closed area boundary
	Oreg_Green	52718	50843	52833	52598	52693
	Oreg_Great	52718	50219	52822	52558	52826
	Oreg_Clarks	52718	49117	52754	52372	51110
	Hatt_Durant	52718	51182	52205	52089	52234
	Hatt_JoeSaur	52718	45262	52619	51603	52516
	Hatt_Brooks	52718	42955	54199	52891	53217
	Ocra_Portsmouth	52718	50303	52947	52695	53594
	Ocra_Royal	52718	48451	52039	51649	52815

Table 6. Percent change in the predicted number of flounder caught during fall from 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

FALL - FLOUNDER	Corridor Expansion Scenarios	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
		No Closure (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed based on previous distribution of effort	Effort redistributed based on distance to closed area boundary
	Oreg_Green	0%	-3.6%	0.2%	-0.2%	0.0%
	Oreg_Great	0%	-4.7%	0.2%	-0.3%	0.2%
	Oreg_Clarks	0%	-6.8%	0.1%	-0.7%	-3.1%
	Hatt_Durant	0%	-2.9%	-1.0%	-1.2%	-0.9%
	Hatt_JoeSaur	0%	-14.1%	-0.2%	-2.1%	-0.4%
	Hatt_Brooks	0%	-18.5%	2.8%	0.3%	0.9%
	Ocra_Portsmouth	0%	-4.6%	0.4%	0.0%	1.7%
	Ocra_Royal	0%	-8.1%	-1.3%	-2.0%	0.2%

Table 7. Predicted number of sea turtles caught during September from 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

SEPTEMBER - SEA TURTLES	Corridor Expansion Scenarios	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
		No corridor expansion (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed based on previous distribution of effort	Effort redistributed based on distance to closed area boundary
	Oreg_Green	42	37	38	38	39
	Oreg_Great	42	36	38	38	39
	Oreg_Clarks	42	34	35	35	36
	Hatt_Durant	42	38	39	39	41
	Hatt_JoeSaur	42	30	36	34	53
	Hatt_Brooks	42	24	26	25	24
	Ocra_Portsmouth	42	39	40	41	39
	Ocra_Royal	42	39	41	43	39

Table 8. Percent change in the observed and predicted number of sea turtles caught during September from 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

SEPTEMBER - SEA TURTLES		Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	Corridor Expansion Scenarios	No corridor expansion (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed based on previous distribution of effort	Effort redistributed based on distance to closed area boundary
	Oreg_Green	0%	-11.9%	-9.5%	-9.5%	-7.1%
	Oreg_Great	0%	-14.3%	-9.5%	-9.5%	-7.1%
	Oreg_Clarks	0%	-19.0%	-16.7%	-16.7%	-14.3%
	Hatt_Durant	0%	-9.5%	-7.1%	-7.1%	-2.4%
	Hatt_JoeSaur	0%	-28.6%	-14.3%	-19.0%	26.2%
	Hatt_Brooks	0%	-42.9%	-38.1%	-40.5%	-42.9%
	Ocra_Portsmouth	0%	-7.1%	-4.8%	-2.4%	-7.1%
	Ocra_Royal	0%	-7.1%	-2.4%	2.4%	-7.1%

Table 9. Analysis of the efficiency of different corridor expansion scenarios under effort redistribution scenarios #3 & #4 during September between 2003 - 2014 in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

SEPTEMBER - SEA TURTLES	Corridor Expansion Scenarios	Expansion Area (km^2)	Effort displaced (yard-days)	Reduction in the number of sea turtles caught		Ratio of sea turtles caught to area closed		Ratio of sea turtles caught to effort displaced		Ratio of sea turtles caught to change in flounder catch	
				Scenario 3	Scenario 4	Scenario 3	Scenario 4	Scenario 3	Scenario 4	Scenario 3	Scenario 4
	Oreg_Green	55	21760	4	3	0.07	0.05	0.00018	0.00014	0.08	0.02
	Oreg_Great	72	30872	4	3	0.06	0.04	0.00013	0.00010	0.03	0.03
	Oreg_Clarks	86	42316	7	6	0.08	0.07	0.00017	0.00014	0.02	0.01
	Hatt_Durant	13	15642	3	1	0.22	0.07	0.00019	0.00006	0.02	0.01
	Hatt_JoeSaur	39	94483	8	-11	0.21	-0.28	0.00008	-0.00012	0.10	-0.03
	Hatt_Brooks	79	130380	17	18	0.21	0.23	0.00013	0.00014	0.18	0.05
	Ocra_Portsmouth	39	18651	1	3	0.03	0.08	0.00005	0.00016	0.01	0.01
	Ocra_Royal	53	26613	-1	3	-0.02	0.06	-0.00004	0.00011	0.00	0.02

Table 10. Predicted number of flounder caught during September from 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

SEPTEMBER - FLOUNDER	Corridor Expansion Scenarios	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
		No corridor expansion (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed based on previous distribution of effort	Effort redistributed based on distance to closed area boundary
	Oreg_Green	17132	16457	17249	17079	17263
	Oreg_Great	17132	16123	17145	16977	17220
	Oreg_Clarks	17132	15691	16989	16790	16451
	Hatt_Durant	17132	16588	16983	16948	16961
	Hatt_JoeSaur	17132	14937	17496	17216	17466
	Hatt_Brooks	17132	14077	17536	17229	17483
	Ocra_Portsmouth	17132	16085	17110	16976	17663
	Ocra_Royal	17132	15336	16553	16386	16952

Table 11. Percent change in the predicted number of flounder caught during September from 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

SEPTEMBER - FLOUNDER		Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	Corridor Expansion Scenarios	**No Closure (current scenario)**	**Effort not redistributed**	**Effort redistributed evenly**	**Effort redistributed based on previous distribution of effort**	**Effort redistributed based on distance to closed area boundary**
	Oreg_Green	0%	-3.9%	0.7%	-0.3%	0.8%
	Oreg_Great	0%	-5.9%	0.1%	-0.9%	0.5%
	Oreg_Clarks	0%	-8.4%	-0.8%	-2.0%	-4.0%
	Hatt_Durant	0%	-3.2%	-0.9%	-1.1%	-1.0%
	Hatt_JoeSaur	0%	-12.8%	2.1%	0.5%	1.9%
	Hatt_Brooks	0%	-17.8%	2.4%	0.6%	2.0%
	Ocra_Portsmouth	0%	-6.1%	-0.1%	-0.9%	3.1%
	Ocra_Royal	0%	-10.5%	-3.4%	-4.4%	-1.1%

Table 12. Predicted number of sea turtles caught during October from 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

OCTOBER - SEA TURTLES	Corridor Expansion Scenarios	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
		No corridor expansion (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed based on previous distribution of effort	Effort redistributed based on distance to closed area boundary
	Oreg_Green	52	49	53	51	59
	Oreg_Great	52	45	50	46	45
	Oreg_Clarks	52	45	53	47	45
	Hatt_Durant	52	51	54	52	54
	Hatt_JoeSaur	52	46	65	54	49
	Hatt_Brooks	52	45	83	61	90
	Ocra_Portsmouth	52	50	52	53	51
	Ocra_Royal	52	45	47	48	45

Table 13. Percent change in the predicted number of sea turtles caught during October from 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

OCTOBER - SEA TURTLES	Corridor Expansion Scenarios	Scenario 0 No corridor expansion (current scenario)	Scenario 1 Effort not redistributed	Scenario 2 Effort redistributed evenly	Scenario 3 Effort redistributed based on previous distribution of effort	Scenario 4 Effort redistributed based on distance to closed area boundary
	Oreg_Green	0%	-5.8%	1.9%	-1.9%	13.5%
	Oreg_Great	0%	-13.5%	-3.8%	-11.5%	-13.5%
	Oreg_Clarks	0%	-13.5%	1.9%	-9.6%	-13.5%
	Hatt_Durant	0%	-1.9%	3.8%	0.0%	3.8%
	Hatt_JoeSaur	0%	-11.5%	25.0%	3.8%	-5.8%
	Hatt_Brooks	0%	-13.5%	59.6%	17.3%	73.1%
	Ocra_Portsmouth	0%	-3.8%	0.0%	1.9%	-1.9%
	Ocra_Royal	0%	-13.5%	-9.6%	-7.7%	-13.5%

Table 14. Analysis of the efficiency of different corridor expansion scenarios under effort redistribution scenarios #3 & #4 during October between 2003 - 2014 in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

OCTOBER - SEA TURTLES	Corridor Expansion Scenarios	Expansion Area (km^2)	Effort displaced (yard-days)	Reduction in the number of sea turtles caught		Ratio of sea turtles caught to area closed		Ratio of sea turtles caught to effort displaced		Ratio of sea turtles caught to change in flounder catch	
				Scenario 3	Scenario 4	Scenario 3	Scenario 4	Scenario 3	Scenario 4	Scenario 3	Scenario 4
	Oreg_Green	55	25820	1	-7	0.02	-0.13	0.00004	-0.00027	0.03	-0.03
	Oreg_Great	72	34732	6	7	0.08	0.10	0.00017	0.00020	1.20	0.05
	Oreg_Clarks	86	53502	5	7	0.06	0.08	0.00009	0.00013	0.04	0.06
	Hatt_Durant	13	22367	0	-2	0.00	-0.15	0.00000	-0.00009	0.00	-0.01
	Hatt_JoeSaur	39	139822	-2	3	-0.05	0.08	-0.00001	0.00002	0.00	0.01
	Hatt_Brooks	79	213436	-9	-38	-0.11	-0.48	-0.00004	-0.00018	-0.01	-0.04
	Ocra_Portsmouth	39	23160	-1	1	-0.03	0.03	-0.00004	0.00004	0.00	0.00
	Ocra_Royal	53	39218	4	7	0.08	0.13	0.00010	0.00018	0.13	0.03

Table 15. Predicted number of flounder caught during October from 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

OCTOBER - FLOUNDER	Corridor Expansion Scenarios	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
		No corridor expansion (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed based on previous distribution of effort	Effort redistributed based on distance to closed area boundary
	Oreg_Green	28734	27809	28754	28699	28469
	Oreg_Great	28734	27525	28821	28729	28579
	Oreg_Clarks	28734	26966	29013	28864	28607
	Hatt_Durant	28734	27777	28427	28348	28389
	Hatt_JoeSaur	28734	24623	28689	28114	28283
	Hatt_Brooks	28734	23387	30211	29359	29686
	Ocra_Portsmouth	28734	27595	28975	28980	29057
	Ocra_Royal	28734	26492	28759	28703	28968

Table 16. Percent change in the predicted number of flounder caught during October from 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.						
OCTOBER - FLOUNDER	**Corridor Expansion Scenarios**	**Scenario 0**	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
		No Closure (current scenario)	**Effort not redistributed**	**Effort redistributed evenly**	**Effort redistributed based on previous distribution of effort**	**Effort redistributed based on distance to closed area boundary**
	Oreg_Green	0%	-3.2%	0.1%	-0.1%	-0.9%
	Oreg_Great	0%	-4.2%	0.3%	0.0%	-0.5%
	Oreg_Clarks	0%	-6.2%	1.0%	0.5%	-0.4%
	Hatt_Durant	0%	-3.3%	-1.1%	-1.3%	-1.2%
	Hatt_JoeSaur	0%	-14.3%	-0.2%	-2.2%	-1.6%
	Hatt_Brooks	0%	-18.6%	5.1%	2.2%	3.3%
	Ocra_Portsmouth	0%	-4.0%	0.8%	0.9%	1.1%
	Ocra_Royal	0%	-7.8%	0.1%	-0.1%	0.8%

Table 17. Predicted number of sea turtles caught during November from 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

NOVEMBER - SEA TURTLES	Corridor Expansion Scenarios	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
		No corridor expansion (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed based on previous distribution of effort	Effort redistributed based on distance to closed area boundary
	Oreg_Green	27	23	24	24	23
	Oreg_Great	27	23	24	24	23
	Oreg_Clarks	27	23	24	24	23
	Hatt_Durant	27	27	27	27	27
	Hatt_JoeSaur	27	23	26	26	25
	Hatt_Brooks	27	21	24	24	21
	Ocra_Portsmouth	27	24	24	24	24
	Ocra_Royal	27	24	24	24	24

Table 18. Percent change in the predicted number of sea turtles caught during November from 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.						
NOVEMBER - SEA TURTLES	Corridor Expansion Scenarios	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
		No corridor expansion (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed based on previous distribution of effort	Effort redistributed based on distance to closed area boundary
	Oreg_Green	0%	-14.8%	-11.1%	-11.1%	-14.8%
	Oreg_Great	0%	-14.8%	-11.1%	-11.1%	-14.8%
	Oreg_Clarks	0%	-14.8%	-11.1%	-11.1%	-14.8%
	Hatt_Durant	0%	0.0%	0.0%	0.0%	0.0%
	Hatt_JoeSaur	0%	-14.8%	-3.7%	-3.7%	-7.4%
	Hatt_Brooks	0%	-22.2%	-11.1%	-11.1%	-22.2%
	Ocra_Portsmouth	0%	-11.1%	-11.1%	-11.1%	-11.1%
	Ocra_Royal	0%	-11.1%	-11.1%	-11.1%	-11.1%

Table 19. Analysis of the efficiency of different corridor expansion scenarios under effort redistribution scenarios #3 & #4 during November between 2003 - 2014 in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

NOVEMBER - SEA TURTLES	Corridor Expansion Scenarios	Expansion Area (km^2)	Effort displaced (yard-days)	Reduction in the number of sea turtles caught		Ratio of sea turtles caught to area closed		Ratio of sea turtles caught to effort displaced		Ratio of sea turtles caught to change in flounder catch	
				Scenario 3	Scenario 4	Scenario 3	Scenario 4	Scenario 3	Scenario 4	Scenario 3	Scenario 4
	Oreg_Green	55	12845	3	4	0.05	0.07	0.00023	0.00031	0.05	0.02
	Oreg_Great	72	13032	3	4	0.04	0.06	0.00023	0.00031	0.05	0.11
	Oreg_Clarks	86	16632	3	4	0.03	0.05	0.00018	0.00024	0.02	0.01
	Hatt_Durant	13	2467	0	0	0.00	0.00	0.00000	0.00000	0.00	0.00
	Hatt_JoeSaur	39	56413	1	2	0.03	0.05	0.00002	0.00004	0.00	0.01
	Hatt_Brooks	79	74126	3	6	0.04	0.08	0.00004	0.00008	0.01	0.01
	Ocra_Portsmouth	39	5400	3	3	0.08	0.08	0.00056	0.00056	0.08	0.10
	Ocra_Royal	53	5400	3	3	0.06	0.06	0.00056	0.00056	0.08	0.08

Table 20. Predicted number of flounder caught during November from 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

NOVEMBER - FLOUNDER		Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	Corridor Expansion Scenarios	**No corridor expansion (current scenario)**	**Effort not redistributed**	**Effort redistributed evenly**	**Effort redistributed based on previous distribution of effort**	**Effort redistributed based on distance to closed area boundary**
	Oreg_Green	6829	6554	6786	6766	6579
	Oreg_Great	6829	6554	6794	6770	6792
	Oreg_Clarks	6829	6443	6745	6701	6472
	Hatt_Durant	6829	6794	6835	6832	6860
	Hatt_JoeSaur	6829	5679	6480	6365	6569
	Hatt_Brooks	6829	5473	6566	6384	6237
	Ocra_Portsmouth	6829	6600	6832	6790	6800
	Ocra_Royal	6829	6600	6832	6790	6793

Table 21. Percent change in the predicted number of flounder caught during November from 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

NOVEMBER - FLOUNDER	Corridor Expansion Scenarios	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
		No Closure (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed based on previous distribution of effort	Effort redistributed based on distance to closed area boundary
	Oreg_Green	0%	-4.0%	-0.6%	-0.9%	-3.7%
	Oreg_Great	0%	-4.0%	-0.5%	-0.9%	-0.5%
	Oreg_Clarks	0%	-5.7%	-1.2%	-1.9%	-5.2%
	Hatt_Durant	0%	-0.5%	0.1%	0.0%	0.5%
	Hatt_JoeSaur	0%	-16.8%	-5.1%	-6.8%	-3.8%
	Hatt_Brooks	0%	-19.9%	-3.9%	-6.5%	-8.7%
	Ocra_Portsmouth	0%	-3.4%	0.0%	-0.6%	-0.4%
	Ocra_Royal	0%	-3.4%	0.0%	-0.6%	-0.5%

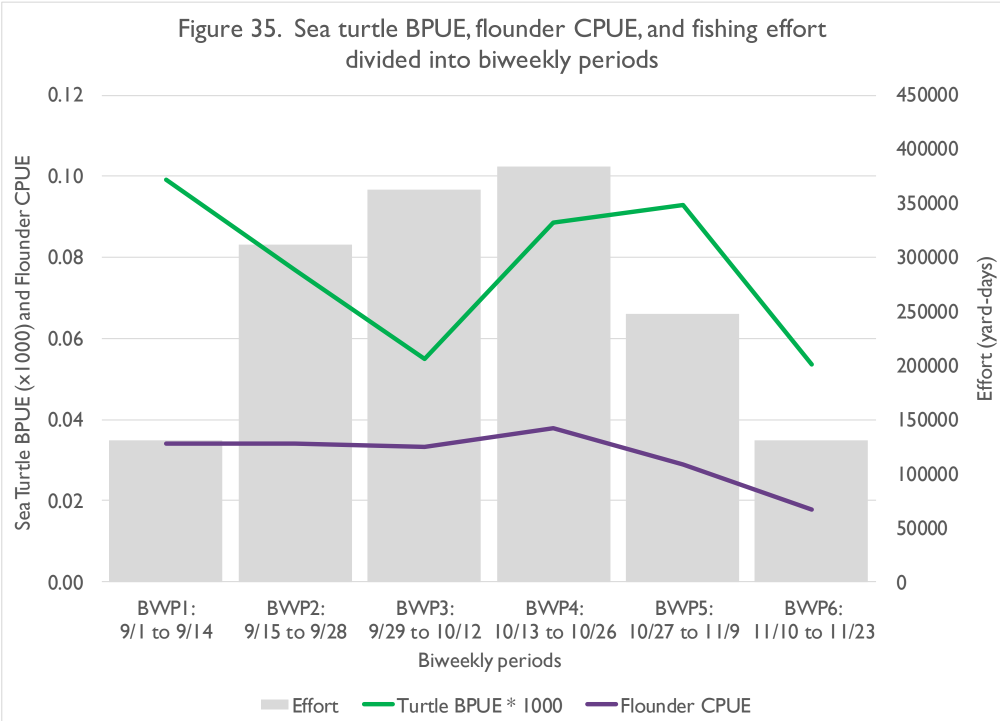


Figure 35. Sea turtle BPUE, flounder CPUE, and fishing effort divided into biweekly periods
0.12
0.10
0.08
0.06
0.04
0.02
0.00
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
Sea Turtle BPUE (x1000) and Flounder CPUE
Effort (yard-days)
BWP1: 9/1 to 9/14
BWP2: 9/15 to 9/28
BWP3: 9/29 to 10/12
BWP4: 10/13 to 10/26
BWP5: 10/27 to 11/9
BWP6: 11/10 to 11/23
Biweekly periods
Effort
Turtle BPUE * 1000
Flounder CPUE

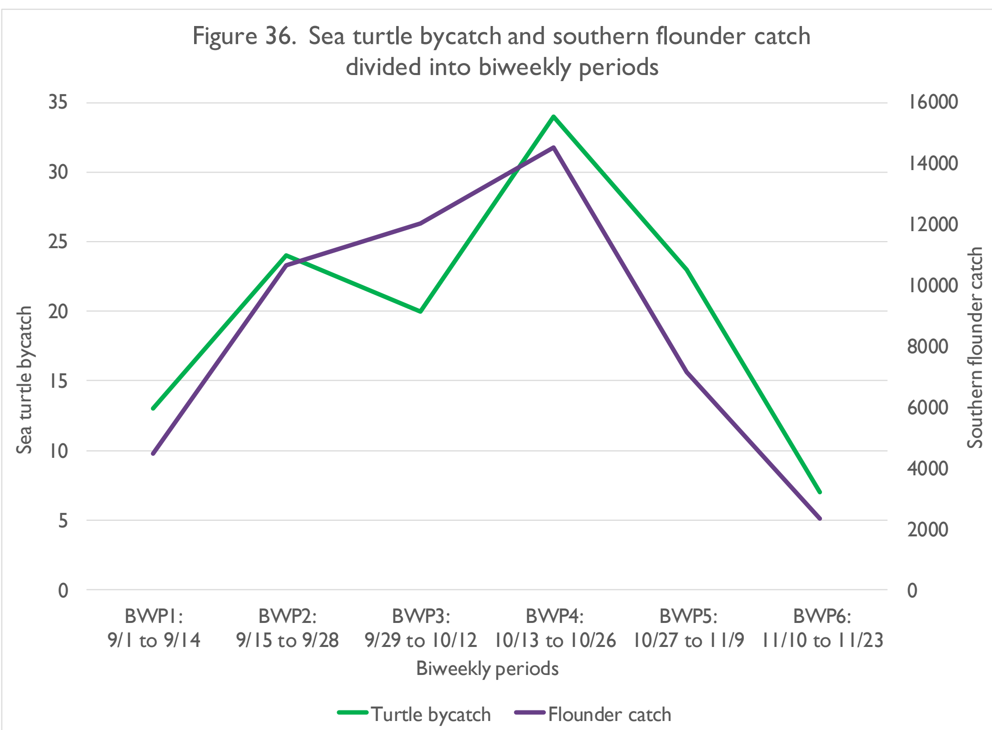


Figure 36. Sea turtle bycatch and southern flounder catch divided into biweekly periods
35
30
25
20
15
10
5
0
16000
14000
12000
10000
8000
6000
4000
2000
0
Sea turtle bycatch
Southern flounder catch
BWP1: 9/1 to 9/14
BWP2: 9/15 to 9/28
BWP3: 9/29 to 10/12
BWP4: 10/13 to 10/26
BWP5: 10/27 to 11/9
BWP6: 11/10 to 11/23
Biweekly periods
Turtle bycatch
Flounder catch

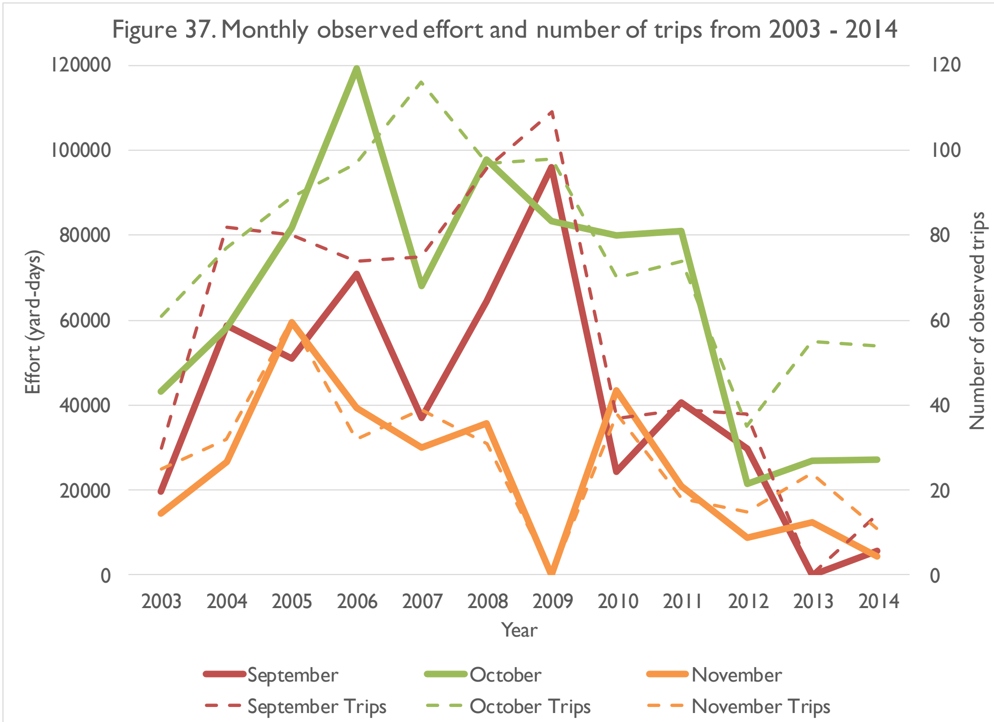


Table 22. Earliest and latest observed trip in Program 466 by year between September and December.

Year	Earliest Date	Latest Date
2003	9/3/2003	12/13/2003
2004	9/1/2004	12/14/2004
2005	9/3/2005	12/8/2005
2006	9/3/2006	11/30/2006
2007	9/1/2007	12/12/2007
2008	9/2/2008	11/26/2008
2009	9/5/2009	12/22/2009
2010	9/7/2010	11/30/2010
2011	9/8/2011	11/30/2011
2012	9/5/2012	11/29/2012
2013	10/1/2013	11/26/2013
2014	9/23/2014	11/20/2014

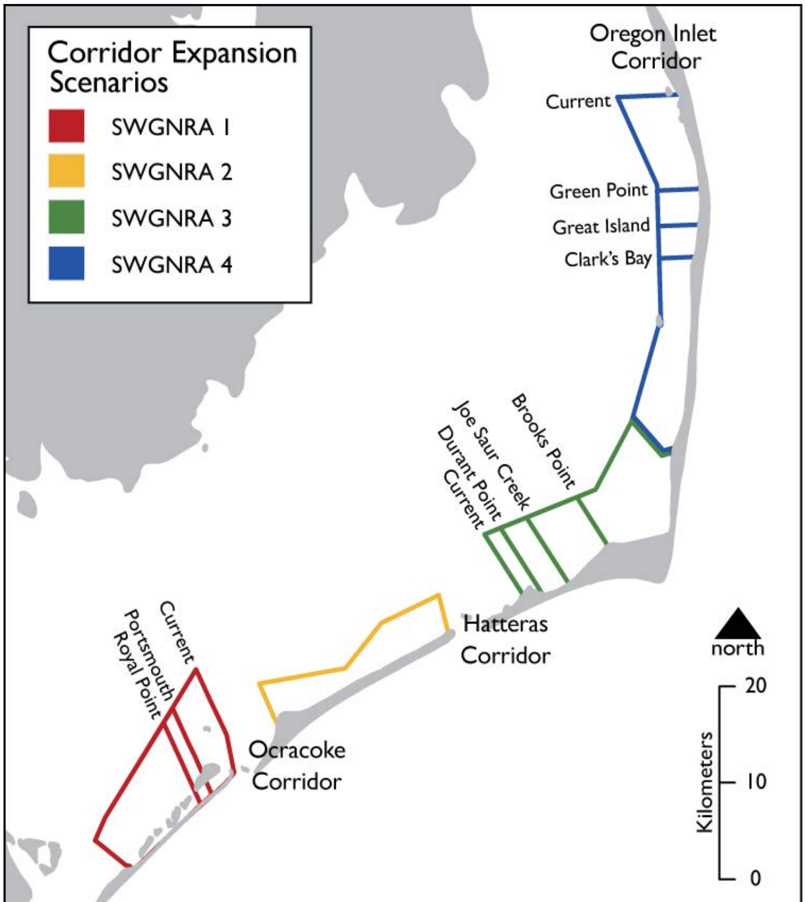
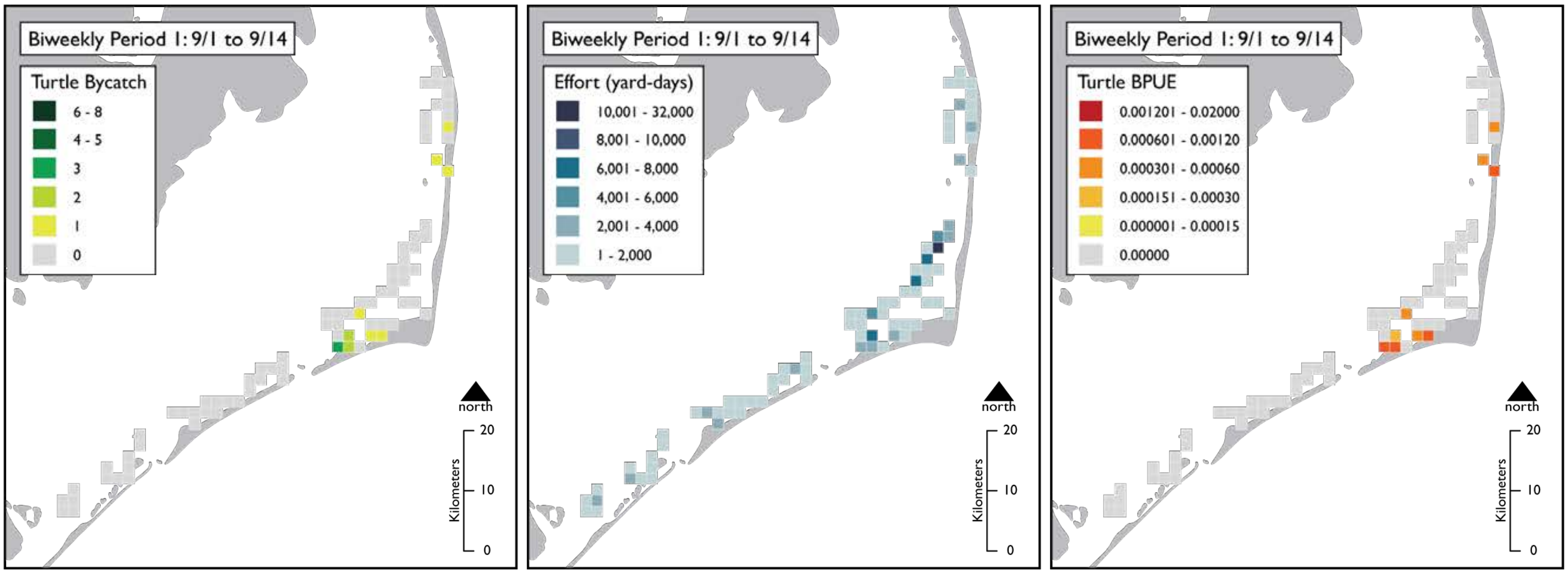


Figure 38. Proposed boundaries of expanded inlet corridors into Pamlico Sound.

Table 23. Corridor expansion scenario names, geographic markers, and coordinates.

Corridor	Scenario Name	Geographic Marker	Latitude	Longitude
Oregon Inlet Corridor	Oreg_Green	Green Point	35.597	-75.472
	Oreg_Great	Great Island	35.531	-75.482
	Oreg_Clarks	Clark's Bay	35.531	-75.482
Hatteras Corridor	Hatt_Durant	Durant Point	35.233	-75.681
	Hatt_JoeSaur	Joe Saur Creek	35.229	-75.639
	Hatt_Brooks	Brooks Point	35.269	-75.596
Ocracoke Corridor	Ocra_Portsmouth	Portsmouth Island/Evergreen Slough	35.069	-76.076
	Ocra_Royal	Royal Point	35.053	-76.088

Figure 39. Sea turtle bycatch, fishing effort, and sea turtle bycatch per unit effort recorded by Program 466 observers during biweekly period 1: 9/1 to 9/14.



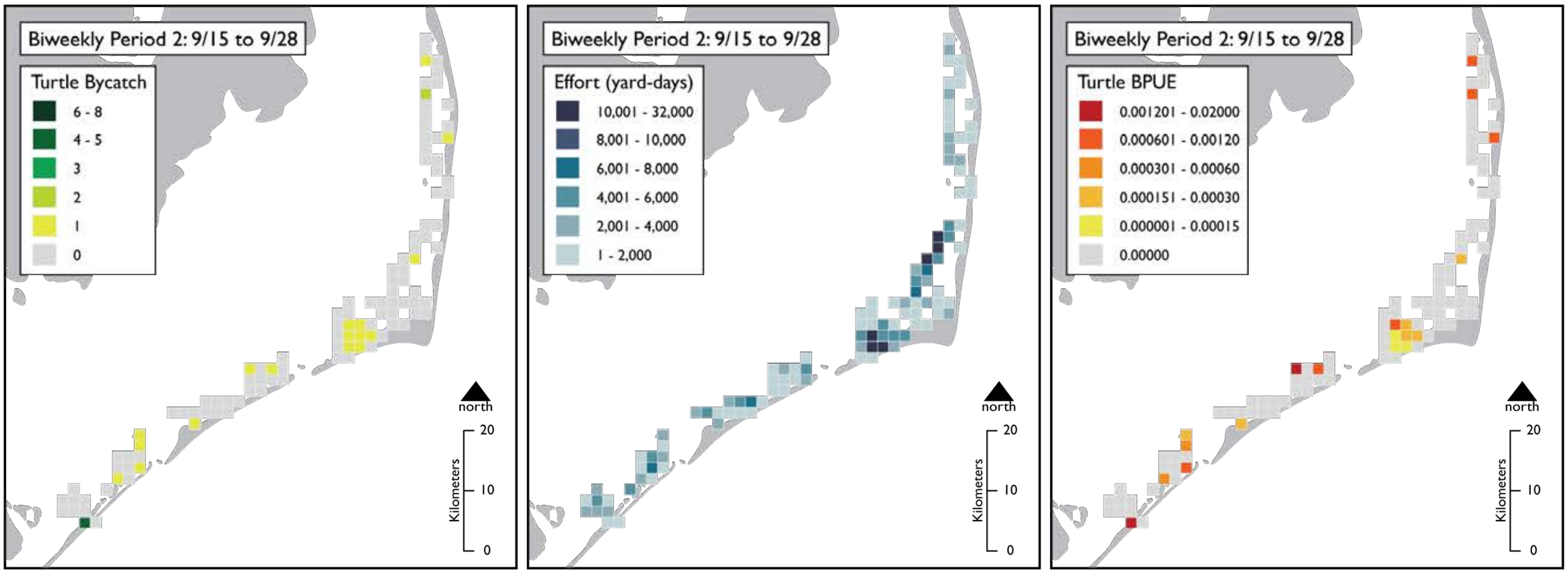


Figure 40. Sea turtle bycatch, fishing effort, and sea turtle bycatch per unit effort recorded by Program 466 observers during biweekly period 2: 9/15 to 9/28.

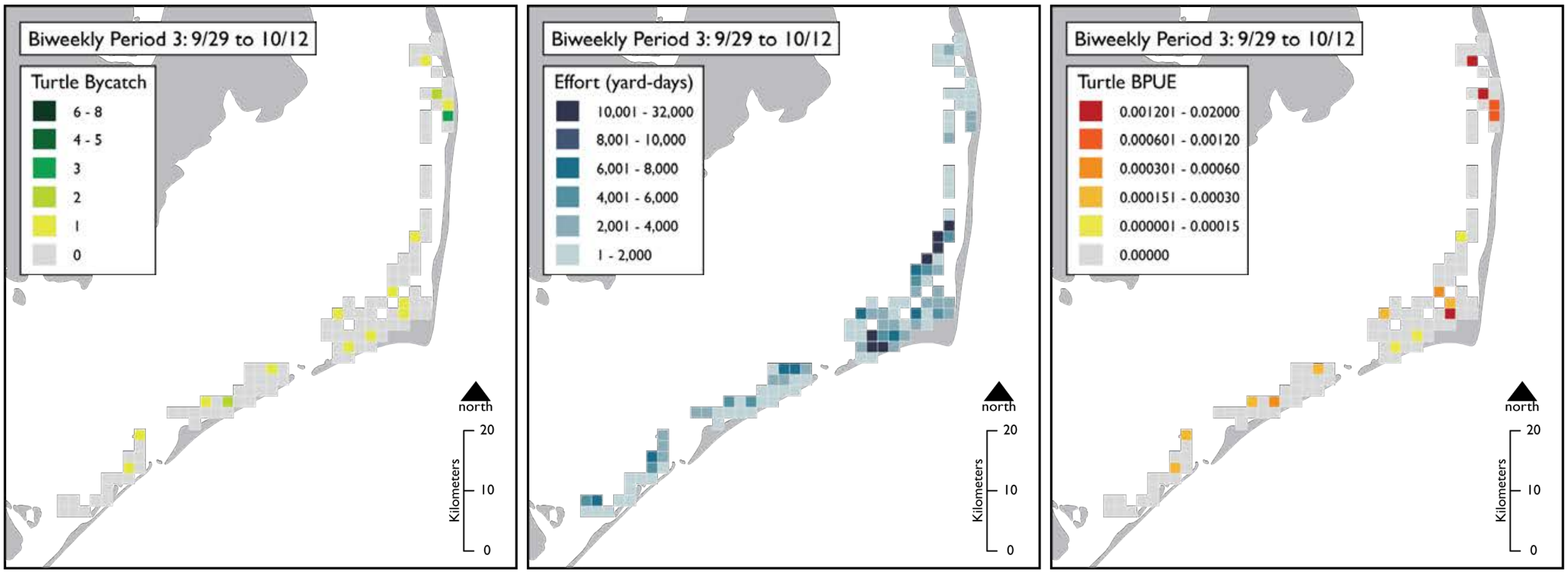


Figure 41. Sea turtle bycatch, fishing effort, and sea turtle bycatch per unit effort recorded by Program 466 observers during biweekly period 3: 9/29 to 10/12.

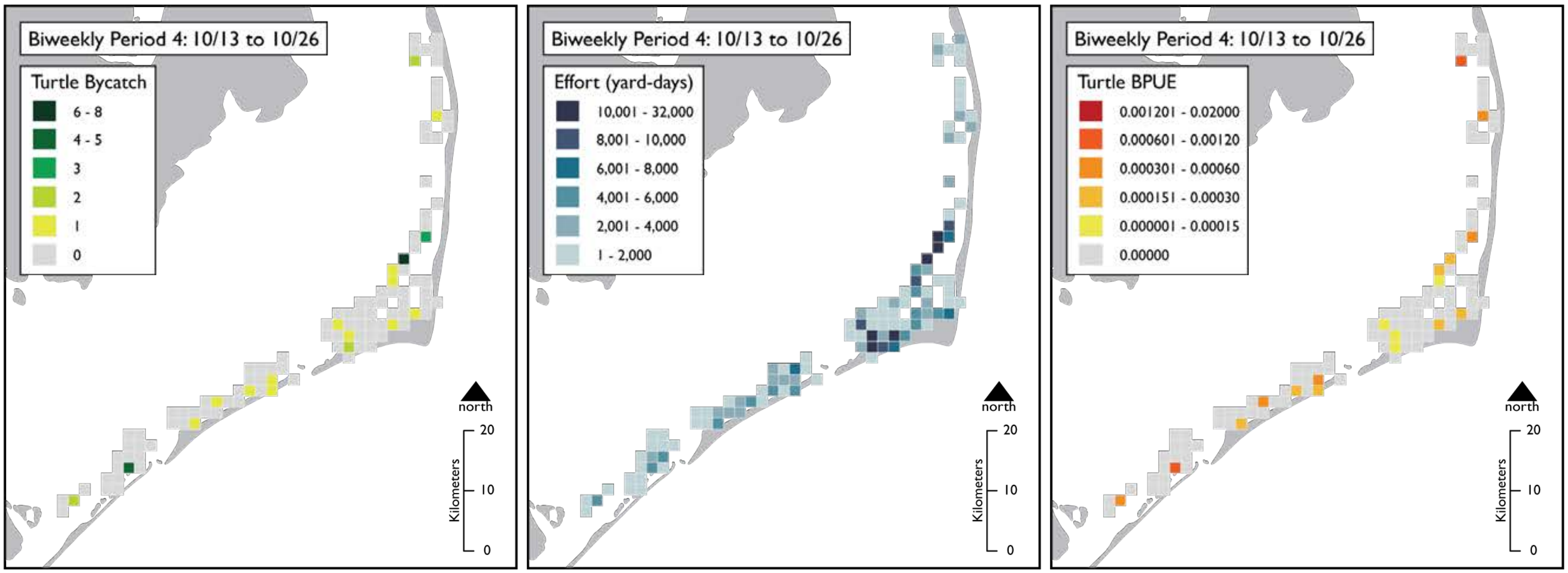


Figure 42. Sea turtle bycatch, fishing effort, and sea turtle bycatch per unit effort recorded by Program 466 observers during biweekly period 4: 10/13 to 10/26.

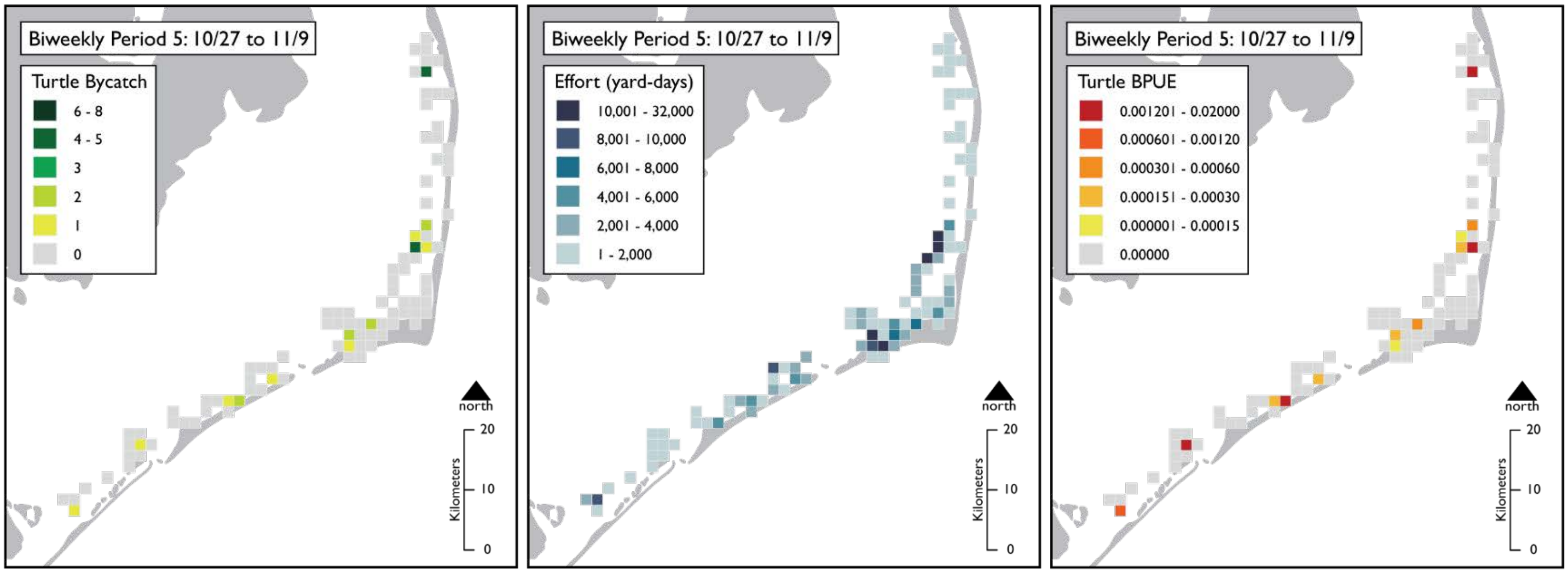


Figure 43. Sea turtle bycatch, fishing effort, and sea turtle bycatch per unit effort recorded by Program 466 observers during biweekly period 3: 10/27 to 11/9.

Figure 44. Sea turtle bycatch, fishing effort, and sea turtle bycatch per unit effort recorded by Program 466 observers during biweekly period 6: 11/10 to 11/23.

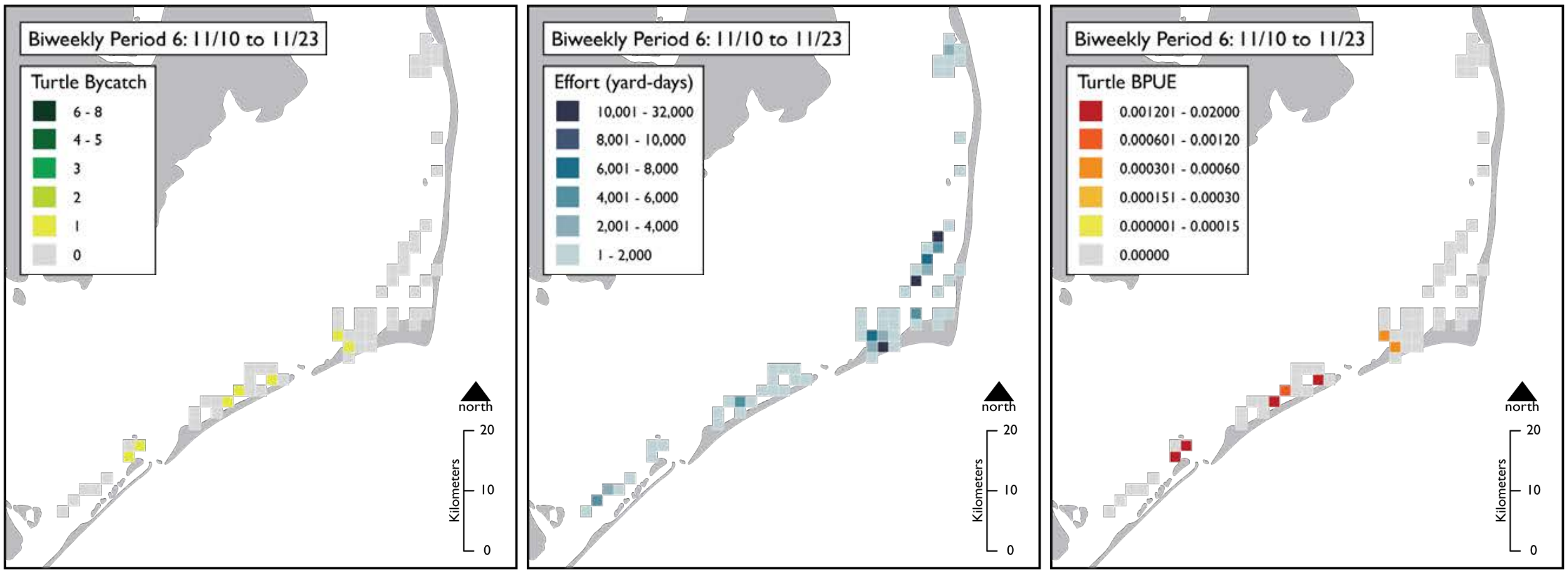


Table 24. Observed fishing effort (yard-days) during years 2003 - 2014 under different corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas assuming displaced effort is not redistributed (i.e. effort redistribution Scenario 1).

	Corridor Expansion Scenarios	9/1 to 9/14	9/15 to 9/28	9/29 to 10/12	10/13 to 10/26	10/27 to 11/9	11/10 to 11/23
EFFORT	No Expansion	131222	312043	363166	383874	247894	130953
	Oreg_Green	125172	299983	351856	369481	238769	124599
	Oreg_Great	121805	296208	345104	365344	238581	124599
	Oreg_Clarks	118700	287869	337483	356994	234381	124399
	Hatt_Durant	124041	304315	354710	373726	242261	129486
	Hatt_JoeSaur	106066	254324	302674	312419	204686	100919
	Hatt_Brooks	96646	232189	275574	275799	178586	95821
	Ocra_Portsmouth	127864	299639	348635	373866	243244	129153
	Ocra_Royal	127627	291914	341776	367018	240894	129153

Table 25. Percent change in observed fishing effort during years 2003 - 2014 under different corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas assuming displaced effort is not redistributed (i.e. effort redistribution Scenario 1).

	Corridor Expansion Scenarios	9/1 to 9/14	9/15 to 9/28	9/29 to 10/12	10/13 to 10/26	10/27 to 11/9	11/10 to 11/23
EFFORT	No Expansion	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Oreg_Green	-4.6%	-3.9%	-3.1%	-3.7%	-3.7%	-4.9%
	Oreg_Great	-7.2%	-5.1%	-5.0%	-4.8%	-3.8%	-4.9%
	Oreg_Clarks	-9.5%	-7.7%	-7.1%	-7.0%	-5.5%	-5.0%
	Hatt_Durant	-5.5%	-2.5%	-2.3%	-2.6%	-2.3%	-1.1%
	Hatt_JoeSaur	-19.2%	-18.5%	-16.7%	-18.6%	-17.4%	-22.9%
	Hatt_Brooks	-26.3%	-25.6%	-24.1%	-28.2%	-28.0%	-26.8%
	Ocra_Portsmouth	-2.6%	-4.0%	-4.0%	-2.6%	-1.9%	-1.4%
	Ocra_Royal	-2.7%	-6.5%	-5.9%	-4.4%	-2.8%	-1.4%

Table 26. Predicted number of sea turtles caught from 9/1 to 9/14 during years 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

	Corridor Expansion Scenarios	Scenario 0 No corridor expansion (current scenario)	Scenario 1 Effort not redistributed	Scenario 2 Effort redistributed evenly	Scenario 3 Effort redistributed proportionally to prior effort	Scenario 4 Effort redistributed proportionally to Flounder CPUE	Scenario 5 Effort redistributed based on distance to closed area boundary
9/1 to 9/14 - SEA TURTLE COUNT	**Oreg_Green**	13	13	13	14	13	13
	Oreg_Great	13	13	14	14	13	14
	Oreg_Clarks	13	12	13	13	13	19
	Hatt_Durant	13	10	11	11	11	13
	Hatt_JoeSaur	13	6	8	8	8	12
	Hatt_Brooks	13	3	3	3	3	3
	Ocra_Portsmouth	13	13	13	13	13	13
	Ocra_Royal	13	13	13	13	13	13

Table 27. Percent change in the predicted number of sea turtles caught from 9/1 to 9/14 during years 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

	Corridor Expansion Scenarios	Scenario 0 No corridor expansion (current scenario)	Scenario 1 Effort not redistributed	Scenario 2 Effort redistributed evenly	Scenario 3 Effort redistributed proportionally to prior effort	Scenario 4 Effort redistributed proportionally to Flounder CPUE	Scenario 5 Effort redistributed based on distance to closed area boundary
9/1 to 9/14 - SEA TURTLE COUNT	**Oreg_Green**	0%	0.0%	0.0%	7.7%	0.0%	0.0%
	Oreg_Great	0%	0.0%	7.7%	7.7%	0.0%	7.7%
	Oreg_Clarks	0%	-7.7%	0.0%	0.0%	0.0%	46.2%
	Hatt_Durant	0%	-23.1%	-15.4%	-15.4%	-15.4%	0.0%
	Hatt_JoeSaur	0%	-53.8%	-38.5%	-38.5%	-38.5%	-7.7%
	Hatt_Brooks	0%	-76.9%	-76.9%	-76.9%	-76.9%	-76.9%
	Ocra_Portsmouth	0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Ocra_Royal	0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 28. Predicted number of flounder caught from 9/1 to 9/14 during years 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.							
9/1 to 9/14 - FLOUNDER COUNT	Corridor Expansion Scenarios	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
		No corridor expansion (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed proportionally to prior effort	Effort redistributed proportionally to Flounder CPUE	Effort redistributed based on distance to closed area boundary
	Oreg_Green	4479	4245	4453	4436	4727	4482
	Oreg_Great	4479	4098	4403	4380	4778	4466
	Oreg_Clarks	4479	3983	4370	4343	4906	4355
	Hatt_Durant	4479	4248	4460	4434	4789	4509
	Hatt_JoeSaur	4479	3773	4513	4418	5748	4855
	Hatt_Brooks	4479	3459	4353	4260	6150	4176
	Ocra_Portsmouth	4479	4284	4432	4411	4531	4560
	Ocra_Royal	4479	4257	4406	4387	4499	4445

Table 29. Percent change in the predicted number of flounder caught from 9/1 to 9/14 during years 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.							
9/1 to 9/14 - FLOUNDER COUNT	Corridor Expansion Scenarios	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
		No corridor expansion (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed proportionally to prior effort	Effort redistributed proportionally to Flounder CPUE	Effort redistributed based on distance to closed area boundary
	Oreg_Green	0%	-5.2%	-0.6%	-1.0%	5.5%	0.1%
	Oreg_Great	0%	-8.5%	-1.7%	-2.2%	6.7%	-0.3%
	Oreg_Clarks	0%	-11.1%	-2.4%	-3.0%	9.5%	-2.8%
	Hatt_Durant	0%	-5.2%	-0.4%	-1.0%	6.9%	0.7%
	Hatt_JoeSaur	0%	-15.8%	0.8%	-1.4%	28.3%	8.4%
	Hatt_Brooks	0%	-22.8%	-2.8%	-4.9%	37.3%	-6.8%
	Ocra_Portsmouth	0%	-4.4%	-1.0%	-1.5%	1.2%	1.8%
	Ocra_Royal	0%	-5.0%	-1.6%	-2.1%	0.4%	-0.8%

Table 30. Predicted number of sea turtles caught from 9/15 to 9/28 during years 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

9/15 to 9/28 - SEA TURTLE COUNT	Corridor Expansion Scenarios	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
		No corridor expansion (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed proportionally to prior effort	Effort redistributed proportionally to Flounder CPUE	Effort redistributed based on distance to closed area boundary
	Oreg_Green	24	21	21	21	22	21
	Oreg_Great	24	21	22	21	22	22
	Oreg_Clarks	24	20	20	20	20	20
	Hatt_Durant	24	23	23	23	23	23
	Hatt_JoeSaur	24	20	22	23	23	27
	Hatt_Brooks	24	17	19	18	21	17
	Ocra_Portsmouth	24	21	22	23	21	21
	Ocra_Royal	24	21	24	25	23	22

Table 31. Percent change in the predicted number of sea turtles caught from 9/15 to 9/28 during years 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

9/15 to 9/28 - SEA TURTLE COUNT	Corridor Expansion Scenarios	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
		No corridor expansion (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed proportionally to prior effort	Effort redistributed proportionally to Flounder CPUE	Effort redistributed based on distance to closed area boundary
	Oreg_Green	0%	-12.5%	-12.5%	-12.5%	-8.3%	-12.5%
	Oreg_Great	0%	-12.5%	-8.3%	-12.5%	-8.3%	-8.3%
	Oreg_Clarks	0%	-16.7%	-16.7%	-16.7%	-16.7%	-16.7%
	Hatt_Durant	0%	-4.2%	-4.2%	-4.2%	-4.2%	-4.2%
	Hatt_JoeSaur	0%	-16.7%	-8.3%	-4.2%	-4.2%	12.5%
	Hatt_Brooks	0%	-29.2%	-20.8%	-25.0%	-12.5%	-29.2%
	Ocra_Portsmouth	0%	-12.5%	-8.3%	-4.2%	-12.5%	-12.5%
	Ocra_Royal	0%	-12.5%	0.0%	4.2%	-4.2%	-8.3%

Table 32. Predicted number of flounder caught from 9/15 to 9/28 during years 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.							
9/15 to 9/28 - FLOUNDER COUNT	**Corridor Expansion Scenarios**	**Scenario 0**	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
		No corridor expansion (current scenario)	**Effort not redistributed**	**Effort redistributed evenly**	**Effort redistributed proportionally to prior effort**	**Effort redistributed proportionally to Flounder CPUE**	**Effort redistributed based on distance to closed area boundary**
	Oreg_Green	10654	10276	10636	10598	11103	10671
	Oreg_Great	10654	10150	10618	10565	11264	10549
	Oreg_Clarks	10654	9828	10496	10401	11465	10249
	Hatt_Durant	10654	10362	10532	10511	10963	10518
	Hatt_JoeSaur	10654	9323	10599	10391	14245	10658
	Hatt_Brooks	10654	8927	10716	10421	16485	11400
	Ocra_Portsmouth	10654	9941	10746	10595	11604	11072
	Ocra_Royal	10654	9218	10211	10069	11159	10748

Table 33. Percent change in the predicted number of flounder caught from 9/15 to 9/28 during years 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.							
9/15 to 9/28 - FLOUNDER COUNT	**Corridor Expansion Scenarios**	**Scenario 0**	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
		No corridor expansion (current scenario)	**Effort not redistributed**	**Effort redistributed evenly**	**Effort redistributed proportionally to prior effort**	**Effort redistributed proportionally to Flounder CPUE**	**Effort redistributed based on distance to closed area boundary**
	Oreg_Green	0%	-3.5%	-0.2%	-0.5%	4.2%	0.2%
	Oreg_Great	0%	-4.7%	-0.3%	-0.8%	5.7%	-1.0%
	Oreg_Clarks	0%	-7.8%	-1.5%	-2.4%	7.6%	-3.8%
	Hatt_Durant	0%	-2.7%	-1.1%	-1.3%	2.9%	-1.3%
	Hatt_JoeSaur	0%	-12.5%	-0.5%	-2.5%	33.7%	0.0%
	Hatt_Brooks	0%	-16.2%	0.6%	-2.2%	54.7%	7.0%
	Ocra_Portsmouth	0%	-6.7%	0.9%	-0.6%	8.9%	3.9%
	Ocra_Royal	0%	-13.5%	-4.2%	-5.5%	4.7%	0.9%

Table 34. Predicted number of sea turtles caught from 9/29 to 10/12 during years 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

9/29 to 10/12 - SEA TURTLE COUNT	Corridor Expansion Scenarios	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
		No corridor expansion (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed proportionally to prior effort	Effort redistributed proportionally to Flounder CPUE	Effort redistributed based on distance to closed area boundary
	Oreg_Green	20	17	18	18	17	20
	Oreg_Great	20	13	13	13	13	13
	Oreg_Clarks	20	13	13	13	13	13
	Hatt_Durant	20	20	20	20	21	20
	Hatt_JoeSaur	20	18	20	20	23	19
	Hatt_Brooks	20	17	20	20	25	23
	Ocra_Portsmouth	20	18	18	18	18	18
	Ocra_Royal	20	18	18	18	18	18

Table 35. Percent change in the predicted number of sea turtles caught from 9/29 to 10/12 during years 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

9/29 to 10/12 - SEA TURTLE COUNT	Corridor Expansion Scenarios	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
		No corridor expansion (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed proportionally to prior effort	Effort redistributed proportionally to Flounder CPUE	Effort redistributed based on distance to closed area boundary
	Oreg_Green	0%	-15.0%	-10.0%	-10.0%	-15.0%	0.0%
	Oreg_Great	0%	-35.0%	-35.0%	-35.0%	-35.0%	-35.0%
	Oreg_Clarks	0%	-35.0%	-35.0%	-35.0%	-35.0%	-35.0%
	Hatt_Durant	0%	0.0%	0.0%	0.0%	5.0%	0.0%
	Hatt_JoeSaur	0%	-10.0%	0.0%	0.0%	15.0%	-5.0%
	Hatt_Brooks	0%	-15.0%	0.0%	0.0%	25.0%	15.0%
	Ocra_Portsmouth	0%	-10.0%	-10.0%	-10.0%	-10.0%	-10.0%
	Ocra_Royal	0%	-10.0%	-10.0%	-10.0%	-10.0%	-10.0%

Table 36. Predicted number of flounder caught from 9/29 to 10/12 during years 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

9/29 to 10/12 - FLOUNDER COUNT	Corridor Expansion Scenarios	Scenario 0 No corridor expansion (current scenario)	Scenario 1 Effort not redistributed	Scenario 2 Effort redistributed evenly	Scenario 3 Effort redistributed proportionally to prior effort	Scenario 4 Effort redistributed proportionally to Flounder CPUE	Scenario 5 Effort redistributed based on distance to closed area boundary
	Oreg_Green	12041	11711	12071	12032	13072	11944
	Oreg_Great	12041	11532	12114	12048	13814	12006
	Oreg_Clarks	12041	11339	12186	12084	14691	12339
	Hatt_Durant	12041	11828	12050	12020	12514	12037
	Hatt_JoeSaur	12041	10628	12226	11997	15890	12304
	Hatt_Brooks	12041	10052	12464	12069	18251	12030
	Ocra_Portsmouth	12041	11271	12262	12114	13010	12560
	Ocra_Royal	12041	10747	12026	11872	12850	12724

Table 37. Percent change in the predicted number of flounder caught from 9/29 to 10/12 during years 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

9/29 to 10/12 - FLOUNDER COUNT	Corridor Expansion Scenarios	Scenario 0 No corridor expansion (current scenario)	Scenario 1 Effort not redistributed	Scenario 2 Effort redistributed evenly	Scenario 3 Effort redistributed proportionally to prior effort	Scenario 4 Effort redistributed proportionally to Flounder CPUE	Scenario 5 Effort redistributed based on distance to closed area boundary
	Oreg_Green	0%	-2.7%	0.2%	-0.1%	8.6%	-0.8%
	Oreg_Great	0%	-4.2%	0.6%	0.1%	14.7%	-0.3%
	Oreg_Clarks	0%	-5.8%	1.2%	0.4%	22.0%	2.5%
	Hatt_Durant	0%	-1.8%	0.1%	-0.2%	3.9%	0.0%
	Hatt_JoeSaur	0%	-11.7%	1.5%	-0.4%	32.0%	2.2%
	Hatt_Brooks	0%	-16.5%	3.5%	0.2%	51.6%	-0.1%
	Ocra_Portsmouth	0%	-6.4%	1.8%	0.6%	8.0%	4.3%
	Ocra_Royal	0%	-10.7%	-0.1%	-1.4%	6.7%	5.7%

Table 38. Predicted number of sea turtles caught from 10/13 to 10/26 during years 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

10/13 to 10/26 - SEA TURTLE COUNT	Corridor Expansion Scenarios	Scenario 0 No corridor expansion (current scenario)	Scenario 1 Effort not redistributed	Scenario 2 Effort redistributed evenly	Scenario 3 Effort redistributed proportionally to prior effort	Scenario 4 Effort redistributed proportionally to Flounder CPUE	Scenario 5 Effort redistributed based on distance to closed area boundary
	Oreg_Green	34	32	34	33	34	39
	Oreg_Great	34	31	33	32	34	31
	Oreg_Clarks	34	31	34	32	35	31
	Hatt_Durant	34	33	34	34	34	34
	Hatt_JoeSaur	34	30	38	36	39	31
	Hatt_Brooks	34	30	45	43	46	44
	Ocra_Portsmouth	34	34	39	37	40	38
	Ocra_Royal	34	29	31	32	32	29

Table 39. Percent change in the predicted number of sea turtles caught from 10/13 to 10/26 during years 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

10/13 to 10/26 - SEA TURTLE COUNT	Corridor Expansion Scenarios	Scenario 0 No corridor expansion (current scenario)	Scenario 1 Effort not redistributed	Scenario 2 Effort redistributed evenly	Scenario 3 Effort redistributed proportionally to prior effort	Scenario 4 Effort redistributed proportionally to Flounder CPUE	Scenario 5 Effort redistributed based on distance to closed area boundary
	Oreg_Green	0%	-5.9%	0.0%	-2.9%	0.0%	14.7%
	Oreg_Great	0%	-8.8%	-2.9%	-5.9%	0.0%	-8.8%
	Oreg_Clarks	0%	-8.8%	0.0%	-5.9%	2.9%	-8.8%
	Hatt_Durant	0%	-2.9%	0.0%	0.0%	0.0%	0.0%
	Hatt_JoeSaur	0%	-11.8%	11.8%	5.9%	14.7%	-8.8%
	Hatt_Brooks	0%	-11.8%	32.4%	26.5%	35.3%	29.4%
	Ocra_Portsmouth	0%	0.0%	14.7%	8.8%	17.6%	11.8%
	Ocra_Royal	0%	-14.7%	-8.8%	-5.9%	-5.9%	-14.7%

Table 40. Predicted number of flounder caught from 10/13 to 10/26 during years 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

10/13 to 10/26 - FLOUNDER COUNT	Corridor Expansion Scenarios	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
		No corridor expansion (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed proportionally to prior effort	Effort redistributed proportionally to Flounder CPUE	Effort redistributed based on distance to closed area boundary
	Oreg_Green	14527	13972	14554	14487	15599	14618
	Oreg_Great	14527	13803	14551	14460	15929	14572
	Oreg_Clarks	14527	13491	14553	14437	16680	14312
	Hatt_Durant	14527	13930	14248	14196	15194	14263
	Hatt_JoeSaur	14527	12192	14468	13993	21914	13971
	Hatt_Brooks	14527	11612	15370	14694	27494	15455
	Ocra_Portsmouth	14527	14058	14725	14697	15145	14811
	Ocra_Royal	14527	13559	14514	14557	14840	14485

Table 41. Percent change in the predicted number of flounder caught from 10/13 to 10/26 during years 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

10/13 to 10/26 - FLOUNDER COUNT	Corridor Expansion Scenarios	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
		No corridor expansion (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed proportionally to prior effort	Effort redistributed proportionally to Flounder CPUE	Effort redistributed based on distance to closed area boundary
	Oreg_Green	0%	-3.8%	0.2%	-0.3%	7.4%	0.6%
	Oreg_Great	0%	-5.0%	0.2%	-0.5%	9.7%	0.3%
	Oreg_Clarks	0%	-7.1%	0.2%	-0.6%	14.8%	-1.5%
	Hatt_Durant	0%	-4.1%	-1.9%	-2.3%	4.6%	-1.8%
	Hatt_JoeSaur	0%	-16.1%	-0.4%	-3.7%	50.9%	-3.8%
	Hatt_Brooks	0%	-20.1%	5.8%	1.1%	89.3%	6.4%
	Ocra_Portsmouth	0%	-3.2%	1.4%	1.2%	4.3%	2.0%
	Ocra_Royal	0%	-6.7%	-0.1%	0.2%	2.2%	-0.3%

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Table 42. Predicted number of sea turtles caught from 10/27 to 11/9 during years 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

10/27 to 11/9 - SEA TURTLE COUNT	Corridor Expansion Scenarios	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
		No corridor expansion (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed proportionally to prior effort	Effort redistributed proportionally to Flounder CPUE	Effort redistributed based on distance to closed area boundary
	Oreg_Green	23	19	20	20	23	19
	Oreg_Great	23	19	21	20	23	19
	Oreg_Clarks	23	19	21	21	25	20
	Hatt_Durant	23	23	23	23	24	23
	Hatt_JoeSaur	23	20	23	23	27	21
	Hatt_Brooks	23	18	23	21	34	18
	Ocra_Portsmouth	23	22	22	22	22	22
	Ocra_Royal	23	22	22	22	22	22

Table 43. Percent change in the predicted number of sea turtles caught from 10/27 to 11/9 during years 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

10/27 to 11/9 - SEA TURTLE COUNT	Corridor Expansion Scenarios	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
		No corridor expansion (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed proportionally to prior effort	Effort redistributed proportionally to Flounder CPUE	Effort redistributed based on distance to closed area boundary
	Oreg_Green	0%	-17.4%	-13.0%	-13.0%	0.0%	-17.4%
	Oreg_Great	0%	-17.4%	-8.7%	-13.0%	0.0%	-17.4%
	Oreg_Clarks	0%	-17.4%	-8.7%	-8.7%	8.7%	-13.0%
	Hatt_Durant	0%	0.0%	0.0%	0.0%	4.3%	0.0%
	Hatt_JoeSaur	0%	-13.0%	0.0%	0.0%	17.4%	-8.7%
	Hatt_Brooks	0%	-21.7%	0.0%	-8.7%	47.8%	-21.7%
	Ocra_Portsmouth	0%	-4.3%	-4.3%	-4.3%	-4.3%	-4.3%
	Ocra_Royal	0%	-4.3%	-4.3%	-4.3%	-4.3%	-4.3%

Table 44. Predicted number of flounder caught from 10/27 to 11/9 during years 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.							
10/27 to 11/9 - FLOUNDER COUNT	**Corridor Expansion Scenarios**	**Scenario 0**	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
		No corridor expansion (current scenario)	**Effort not redistributed**	**Effort redistributed evenly**	**Effort redistributed proportionally to prior effort**	**Effort redistributed proportionally to Flounder CPUE**	**Effort redistributed based on distance to closed area boundary**
	Oreg_Green	7162	6900	7097	7082	7618	6950
	Oreg_Great	7162	6900	7102	7086	7633	7173
	Oreg_Clarks	7162	6781	7070	7037	7884	6929
	Hatt_Durant	7162	6974	7094	7083	7332	7136
	Hatt_JoeSaur	7162	6104	6914	6867	8475	6711
	Hatt_Brooks	7162	5673	7031	6933	9770	6708
	Ocra_Portsmouth	7162	6955	7270	7224	7499	7188
	Ocra_Royal	7162	6871	7382	7298	7722	7215

Table 45. Percent change in the predicted number of flounder caught from 10/27 to 11/9 during years 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.							
10/27 to 11/9 - FLOUNDER COUNT	**Corridor Expansion Scenarios**	**Scenario 0**	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
		No corridor expansion (current scenario)	**Effort not redistributed**	**Effort redistributed evenly**	**Effort redistributed proportionally to prior effort**	**Effort redistributed proportionally to Flounder CPUE**	**Effort redistributed based on distance to closed area boundary**
	Oreg_Green	0%	-3.7%	-0.9%	-1.1%	6.4%	-3.0%
	Oreg_Great	0%	-3.7%	-0.8%	-1.1%	6.6%	0.2%
	Oreg_Clarks	0%	-5.3%	-1.3%	-1.7%	10.1%	-3.3%
	Hatt_Durant	0%	-2.6%	-0.9%	-1.1%	2.4%	-0.4%
	Hatt_JoeSaur	0%	-14.8%	-3.5%	-4.1%	18.3%	-6.3%
	Hatt_Brooks	0%	-20.8%	-1.8%	-3.2%	36.4%	-6.3%
	Ocra_Portsmouth	0%	-2.9%	1.5%	0.9%	4.7%	0.4%
	Ocra_Royal	0%	-4.1%	3.1%	1.9%	7.8%	0.7%

Table 46. Predicted number of sea turtles caught from 11/10 to 11/23 during years 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

11/10 to 11/23 - SEA TURTLE COUNT	Corridor Expansion Scenarios	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
		No corridor expansion (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed proportionally to prior effort	Effort redistributed proportionally to Flounder CPUE	Effort redistributed based on distance to closed area boundary
	Oreg_Green	7	7	7	7	7	7
	Oreg_Great	7	7	7	7	7	7
	Oreg_Clarks	7	7	7	7	7	7
	Hatt_Durant	7	7	7	7	7	7
	Hatt_JoeSaur	7	5	5	5	5	5
	Hatt_Brooks	7	5	5	5	5	5
	Ocra_Portsmouth	7	5	5	5	5	5
	Ocra_Royal	7	5	5	5	5	5

Table 47. Percent change in the predicted number of sea turtles caught from 11/10 to 11/23 during years 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

11/10 to 11/23 - SEA TURTLE COUNT	Corridor Expansion Scenarios	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
		No corridor expansion (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed proportionally to prior effort	Effort redistributed proportionally to Flounder CPUE	Effort redistributed based on distance to closed area boundary
	Oreg_Green	0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Oreg_Great	0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Oreg_Clarks	0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Hatt_Durant	0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Hatt_JoeSaur	0%	-28.6%	-28.6%	-28.6%	-28.6%	-28.6%
	Hatt_Brooks	0%	-28.6%	-28.6%	-28.6%	-28.6%	-28.6%
	Ocra_Portsmouth	0%	-28.6%	-28.6%	-28.6%	-28.6%	-28.6%
	Ocra_Royal	0%	-28.6%	-28.6%	-28.6%	-28.6%	-28.6%

Table 48. Predicted number of flounder caught from 11/10 to 11/23 during years 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

11/10 to 11/23 - FLOUNDER COUNT	Corridor Expansion Scenarios	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
		No corridor expansion (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed proportionally to prior effort	Effort redistributed proportionally to Flounder CPUE	Effort redistributed based on distance to closed area boundary
	Oreg_Green	2316	2217	2345	2336	2702	2234
	Oreg_Great	2316	2217	2345	2336	2702	2241
	Oreg_Clarks	2316	2216	2349	2340	2717	2235
	Hatt_Durant	2316	2287	2312	2308	2509	2325
	Hatt_JoeSaur	2316	1675	2088	1985	7961	1907
	Hatt_Brooks	2316	1633	2122	2004	9463	2092
	Ocra_Portsmouth	2316	2258	2312	2291	2359	2308
	Ocra_Royal	2316	2258	2312	2291	2359	2306

Table 49. Percent change in the predicted number of flounder caught from 11/10 to 11/23 during years 2003 - 2014 under different effort redistribution & corridor expansion scenarios in the Pamlico Sound Shallow Water Gillnet Restricted Areas.

11/10 to 11/23 - FLOUNDER COUNT	Corridor Expansion Scenarios	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
		No corridor expansion (current scenario)	Effort not redistributed	Effort redistributed evenly	Effort redistributed proportionally to prior effort	Effort redistributed proportionally to Flounder CPUE	Effort redistributed based on distance to closed area boundary
	Oreg_Green	0%	-4.3%	1.3%	0.9%	16.7%	-3.5%
	Oreg_Great	0%	-4.3%	1.3%	0.9%	16.7%	-3.2%
	Oreg_Clarks	0%	-4.3%	1.4%	1.0%	17.3%	-3.5%
	Hatt_Durant	0%	-1.3%	-0.2%	-0.3%	8.3%	0.4%
	Hatt_JoeSaur	0%	-27.7%	-9.8%	-14.3%	243.7%	-17.7%
	Hatt_Brooks	0%	-29.5%	-8.4%	-13.5%	308.6%	-9.7%
	Ocra_Portsmouth	0%	-2.5%	-0.2%	-1.1%	1.9%	-0.3%
	Ocra_Royal	0%	-2.5%	-0.2%	-1.1%	1.9%	-0.4%

Figure 45. Sea turtle bycatch per unit effort (BPUE) for observed hauls (only those with water temperature recorded) by day of year in the Pamlico Sound Shallow Water Gill Net Restricted Areas.

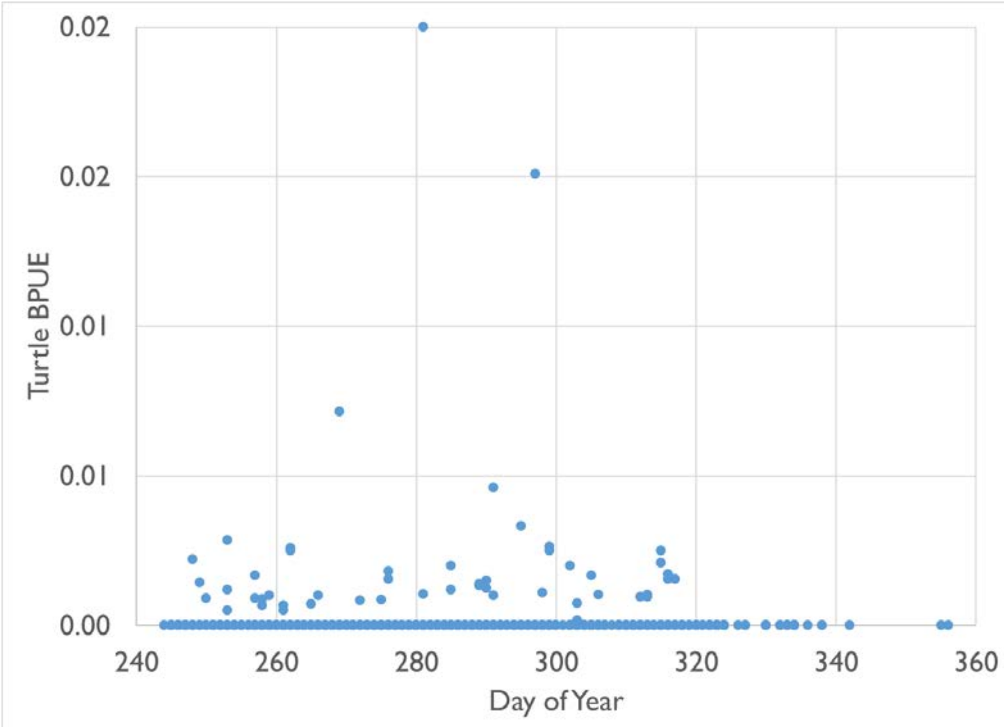

Figure 46. Sea turtle bycatch per unit effort (BPUE) for observed hauls by water temperature in the Pamlico Sound Shallow Water Gill Net Restricted Areas.

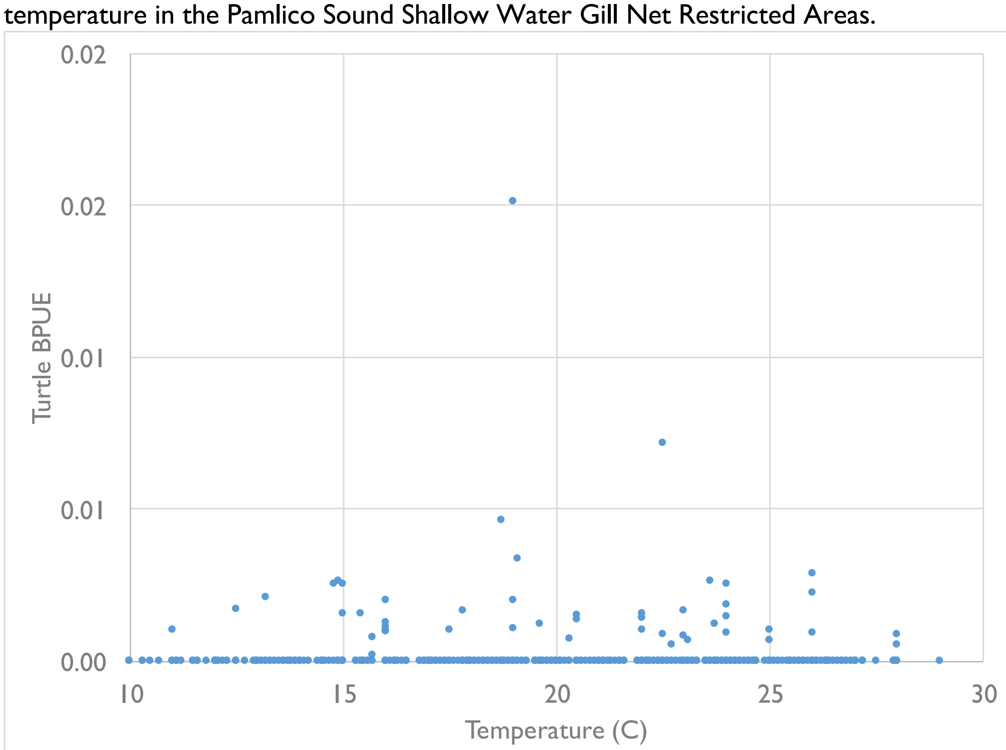

Figure 47. Recorded water temperature and day of year of observed hauls in the Pamlico Sound Shallow Water Gill Net Restricted Areas.

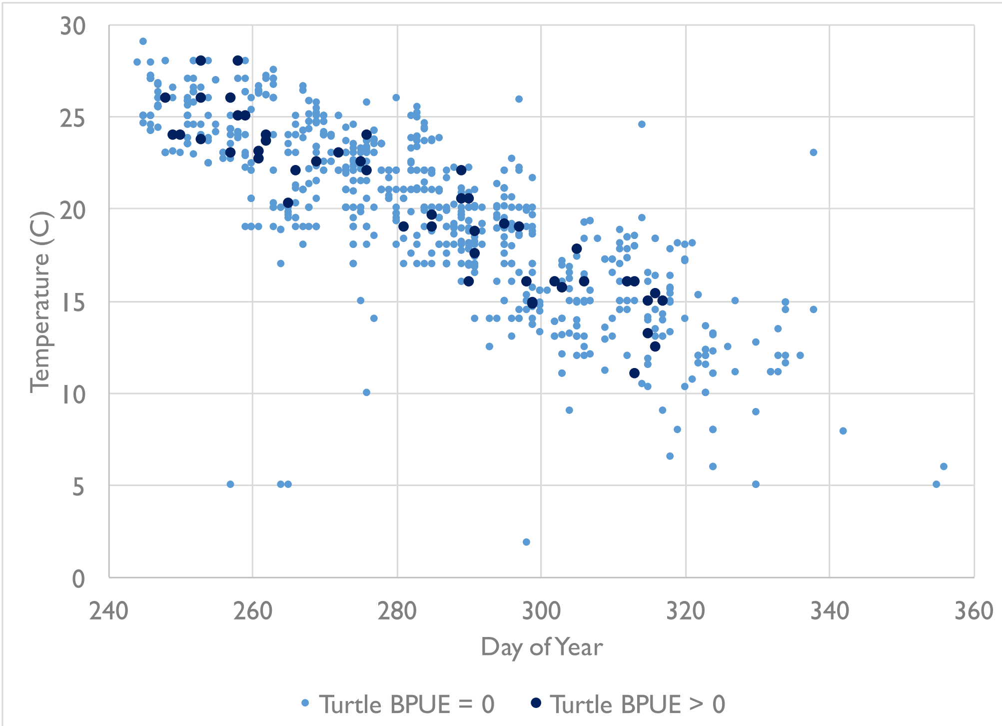

Figure 48. Average water temperature for observed hauls in the Pamlico Sound Shallow Water Gill Net Restricted Areas.

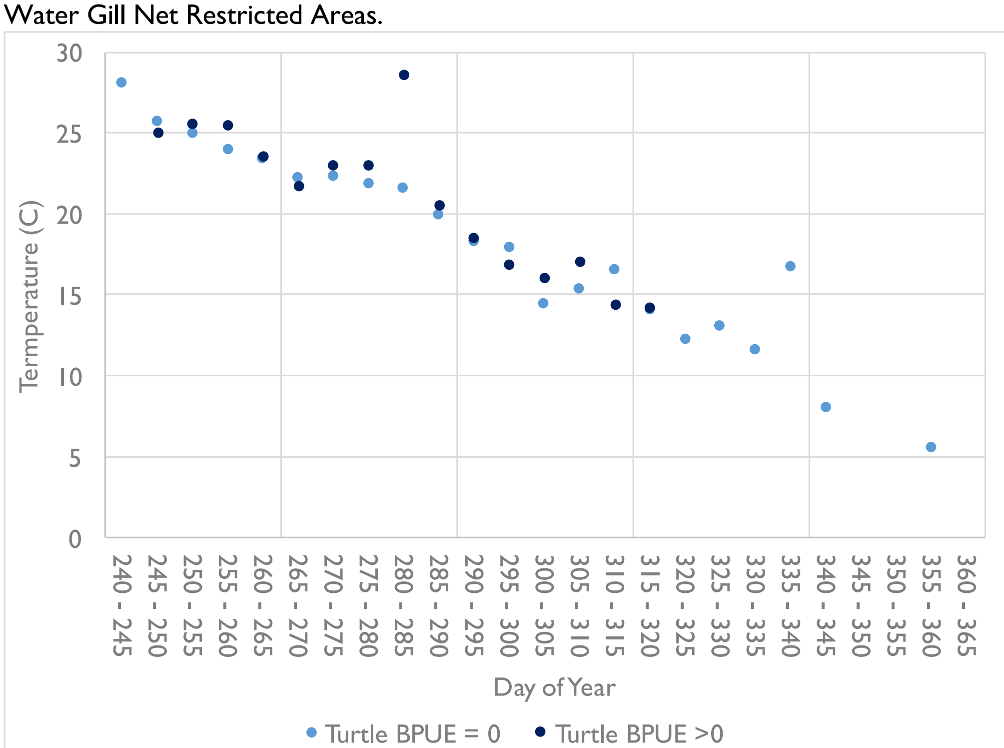

Figure 49. Number of observed hauls (only those with water temperature recorded) by day of year in the Pamlico Sound Shallow Water Gill Net Restricted Areas.

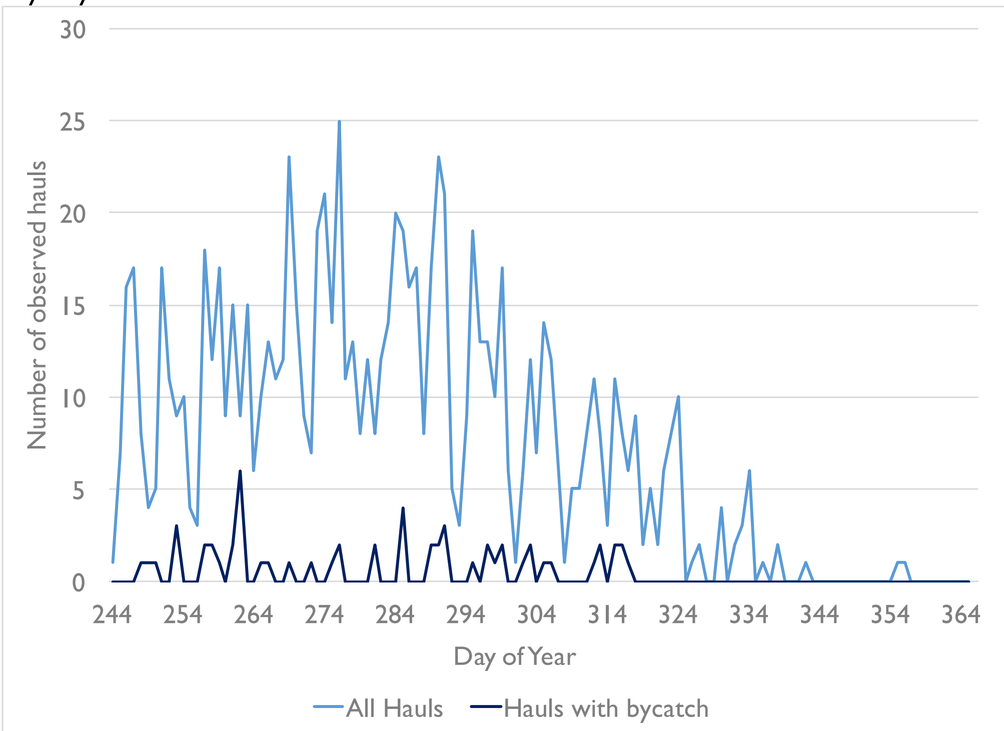

Figure 50. Effort and sea turtle bycatch per unit effort (BPUE) (only hauls with water temperature recorded) by day of year in the Pamlico Sound Shallow Water Gill Net Restricted Areas.

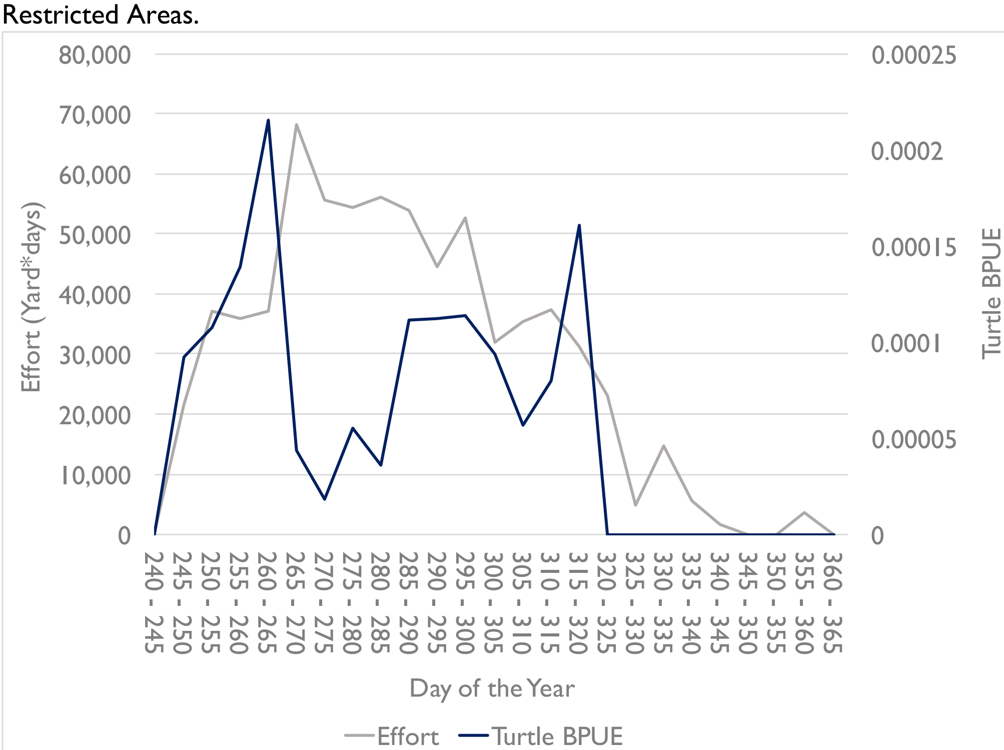

Figure 51. Number of observed hauls by water temperature in the Pamlico Sound Shallow Water Gill Net Restricted Areas.

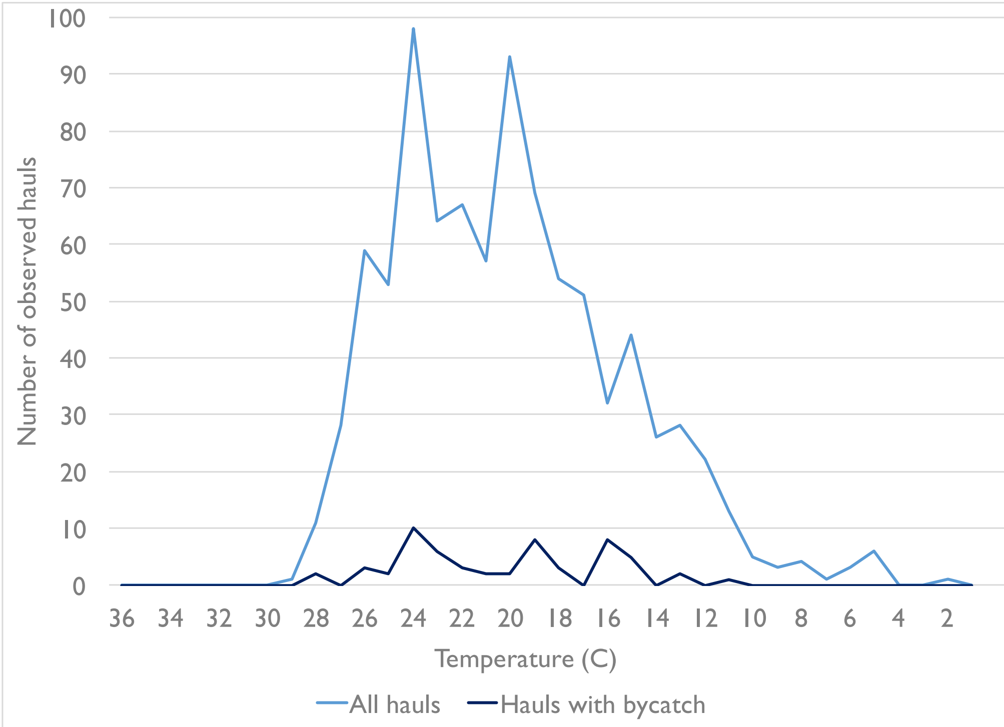

Figure 52. Effort and sea turtle bycatch per unit effort (BPUE) by water temperature in the Pamlico Sound Shallow Water Gill Net Restricted Areas.