



Department of Defense Legacy Resource Management Program

Legacy 09-428

**DETERMINING MARINE MIGRATION PATTERNS &
BEHAVIOR OF GULF STURGEON IN THE GULF OF
MEXICO OFF OF EGLIN AIR FORCE BASE
Technical Report**

**Science Applications International Corporation
Eglin Natural Resources Section
Eglin Air Force Base, Florida**

September 2010

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SEPTEMBER 2010

EXECUTIVE SUMMARY

The Eglin Natural Resources Section (NRS) received funding from the Department of Defense Legacy Resource Management Program (MIPR W31RYO90230101) to determine migration patterns and behavior of the Gulf sturgeon (*Acipenser oxyrinchus desotoi*) within critical habitat areas of Eglin's Gulf Test and Training Range (EGTTR) in the Gulf of Mexico. The study was conducted between September 2009 and May 2010. A Pilot Study was conducted in 2008 in cooperation with the U.S. Fish and Wildlife Service (USFWS), U.S. Geological Survey (USGS), and Florida Fish and Wildlife Conservation Commission (FWC). Forty adult Gulf sturgeon were tagged from the Choctawhatchee River and their movements were tracked by thirteen receivers placed in strategic locations in the Choctawhatchee Bay, Gulf of Mexico, and Santa Rosa Sound. The results of the Pilot Study provided the foundation for the 2009-2010 Legacy Study (Number 09-428) where Eglin used similar methodologies but expanded the scope of the study for a more robust data set and a wider range of coverage of the Gulf of Mexico.

In 2009, forty more Gulf sturgeon were tagged from the Yellow River (12 adults), Blackwater River (25 adults), and Escambia River (3 adults). Twenty-one receivers were deployed in marine, estuarine, and riverine areas surrounding Eglin's properties, including the Gulf of Mexico, Santa Rosa Sound, Pensacola Bay, and Yellow, Blackwater, and Escambia Rivers. The receivers were deployed in an arrangement that would detect sturgeon movement in riverine, estuarine, and marine environments from Destin, Florida to Perdido Key, Alabama. This configuration allowed data collection in areas heavily utilized for military testing and training activities. These receivers were able to detect Gulf sturgeon tagged by Eglin in 2008 and 2009, as well as sturgeon tagged by other researchers utilizing the same acoustic technology.

The combined efforts of the 2008 Pilot Study and the 2009 Legacy Study have allowed Eglin to determine Gulf sturgeon presence and movement patterns within critical habitat areas surrounding Eglin Air Force Base. Gulf sturgeon occurrence in the Gulf of Mexico offshore of Eglin's properties has been confirmed to be within 1,000 meters of the shoreline. Furthermore, the data collected from the receivers indicates that sturgeon activity in critical habitat areas of the EGTTR begins in November, peaks in December and January, and lasts through April. Results from this work will allow the Department of Defense to more accurately determine potential impacts to Gulf sturgeon from military activities in the EGTTR and develop effective mitigation measures that can be included in Section 7 Consultations under the Endangered Species Act.

Other important topics addressed in the report include movement patterns of Gulf sturgeon from different river systems, identification of potential hot spots within the Gulf of Mexico portion of the study area, river fidelity of the Gulf sturgeon in this sample, and level of performance of the acoustic technology utilized in this study in a harsh marine environment.

I. Introduction

The Gulf sturgeon is an anadromous fish occurring in riverine, estuarine, and nearshore marine environments of coastal states along the Gulf of Mexico. Sturgeon have bony plates (called scutes) instead of scales, and an extended snout. Adults range in length from four to eight feet. The species' freshwater range encompasses seven river systems from Lake Pontchartrain in Louisiana to the Suwannee River in Florida. Gulf sturgeon occur primarily in riverine environments during warm months (approximately April to October), where spawning occurs. Sturgeon generally do not feed in the riverine habitats. During early fall, a portion of the Gulf sturgeon population (presumably mostly adults or sub-adults) migrates into nearshore marine waters to forage and overwinter, and remains in this habitat until early to late spring. Some individuals have been documented in estuarine waters such as bays and sounds for at least a portion of the fall and winter months, although the extent of this habitat use is not well studied. Feeding occurs on the bottom sediments of marine and estuarine habitats. Prey items consist primarily of macroinvertebrates such as brachiopods, mollusks, worms, and crustaceans.

The Gulf sturgeon was listed as a threatened species in 1991 under the federal Endangered Species Act of 1973 (ESA). Critical habitat for the species was designated in 2003. Critical habitat is defined as specific areas that are considered essential to the conservation of a listed species due to the presence of primary constituent elements, and that may require special management considerations or protection. Gulf sturgeon critical habitat consists of 7 geographic areas (units) of riverine habitat and 7 units of estuarine and marine habitat, for a total of 14 units (Figure 1). Critical habitat of the river units extends to the river mouths and up to the ordinary high water line. Estuarine habitat consists of several lakes, bays, and sounds. Gulf of Mexico critical habitat extends from the shoreline out to one nautical mile offshore.

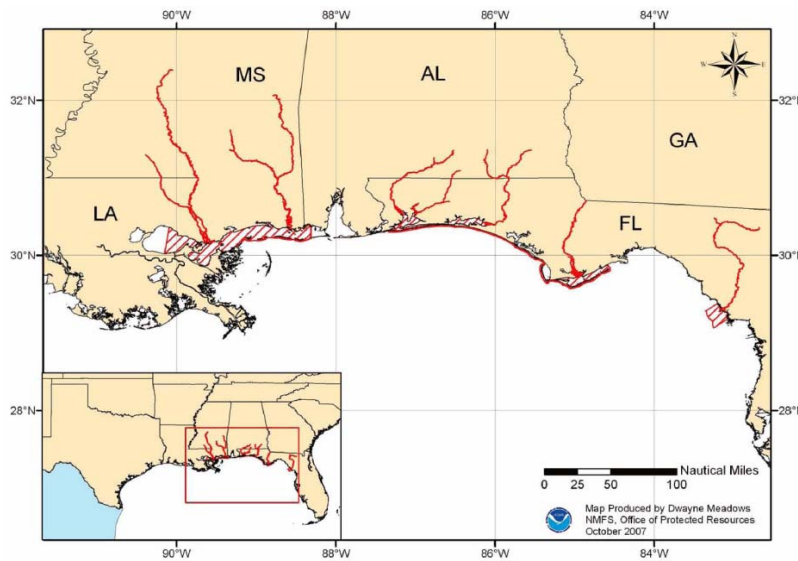


Figure 1. Gulf Sturgeon Critical Habitat (NMFS, 2010)

I. Background

Section 7 of the ESA requires all federal agencies to insure that actions authorized, funded, or carried out by the agency are not likely to jeopardize the continued existence of an endangered or threatened species or result in the destruction or adverse modification of critical habitat. As a federal agency, the Department of Defense (DoD) typically complies with these requirements by conducting Section 7 consultations with the National Marine Fisheries Service (NMFS) and/or the U.S. Fish and Wildlife Service (USFWS) when testing, training, or construction activities have the potential to impact Gulf sturgeon or adversely modify critical habitat. Eglin Air Force Base (AFB) schedules military activities (including Air Force, Army, Navy, and Marine Corps testing and training missions) within several areas that could result in impacts to Gulf sturgeon, including potential impacts to designated critical habitat. These areas include the Eglin Gulf Test and Training Range (EGTTR) in the Gulf of Mexico, Santa Rosa Sound, Choctawhatchee Bay, and the Yellow and Shoal Rivers. Several mission sets are currently in progress or have recently been completed within Gulf sturgeon critical habitat. Therefore, Eglin AFB expects that consultations with the Services will continue to be required in the future due to potential impacts to Gulf sturgeon and critical habitat.

Although information on Gulf sturgeon distribution and behavior in riverine habitats is lacking to some degree, occurrence patterns are understood well enough to reasonably evaluate the effects of human activities on the species. Conversely, little has historically been known of the occurrence, spatial distribution, and movement patterns of Gulf sturgeon in the marine environment of the Gulf of Mexico, resulting in a scarcity of scientific data available for use during consultations. In response to this lack of information, Eglin AFB conducted a pilot research project in 2008 to determine the presence or absence, location, and timing of movement of sturgeon in Gulf of Mexico critical habitat near Eglin. The project included cooperative efforts of the Air Force, USFWS, U.S. Geological Survey (USGS), and Florida Fish and Wildlife Conservation Commission (FWC). Based on the results of the 2008 Pilot Study, Eglin AFB expanded the scope of the study in 2009 and received funding from the DoD's Legacy Resource Management Program (Number 09-428). A summary of the results of the 2008 Pilot Study and the results of the 2009 Legacy Study are discussed and included in this report.

II. Methodology for FY 2008 Pilot Study



Figure 2.
Vemco® V16 tag

For the 2008 Pilot Study, Eglin worked with the USFWS to surgically implant 40 Vemco® V16 coded acoustic transmitters into the abdominal cavities of Gulf sturgeon captured in the Choctawhatchee River system. Each acoustic transmitter, or tag, was set to emit a transmission, or ping, once every 30 to 90 seconds (with a nominal time of 60 seconds). The Vemco® V16 tags are about 3 inches long and have a battery life of around 3 to 5 years, depending on the ping interval. The sturgeon that were targeted for tagging were adults that weighed at least 50 pounds, since these individuals are most likely to overwinter in the Gulf. Table 1

shows the tag ID, weight, fork length, and the tag date for each sturgeon tagged for the 2008 Pilot Study.

Table 1. Information on Sturgeon tagged in the Choctawhatchee River for the 2008 Pilot Study

Vemco® Tag ID	Fork length (inches)	Weight (lbs)	Date Tagged
51884	68.50	100.00	9/9/2008
51885	75.20	125.22	10/13/2008
51886	70.75	94.25	9/15/2008
51887	60.00	61.60	10/26/2008
51888	59.20	58.75	10/13/2008
51889	57.48	49.60	10/25/2008
51890	72.00	120.00	10/12/2008
51891	69.00	94.00	10/26/2008
51892	71.00	106.00	10/11/2008
51893	58.00	51.75	9/15/2008
51894	56.00	60.50	9/15/2008
51895	58.50	63.50	8/14/2008
51896	66.50	90.50	8/12/2008
51897	54.50	50.25	8/14/2008
51898	54.50	54.50	8/14/2008
51899	65.00	83.00	8/14/2008
51890	70.50	107.75	8/14/2008
51900	70.47	106.92	8/14/2008
51901	74.50	120.00	8/14/2008
51902	77.25	123.00	8/14/2008
51903	67.75	101.50	9/9/2008
51904	72.00	93.25	9/9/2008
51905	60.00	53.25	9/9/2008
51906	57.50	54.00	9/9/2008
51907	56.00	54.25	8/12/2008
51908	56.00	54.25	8/12/2008
51909	69.50	86.25	8/12/2008
51910	64.00	142.00	8/12/2008
51911	56.00	130.25	8/5/2008
51912	61.50	65.50	7/31/2008
51913	67.00	99.50	8/5/2008
51914	63.00	69.50	8/5/2008
51915	74.50	130.00	8/8/2008
51916	71.50	132.00	8/12/2008
51917	67.75	103.75	8/8/2008
51918	61.50	60.50	8/8/2008
51919	71.00	110.00	7/31/2008
51920	66.00	91.50	7/31/2008
51921	61.00	64.00	7/31/2008
51922	75.00	113.50	7/31/2008

To track the sturgeon’s movements, Eglin used Vemco® VR2W data-logging hydrophones, or receivers that were placed in strategic locations and can receive the transmissions emitted from tagged individuals. The tags emit an ultrasonic acoustic pulse that is unique to each unit, so that individual transmitters (i.e., individual fish) can be distinguished. The receivers detect and record these acoustic



Figure 3. Receiver/buoy assembly

pulses, along with associated data such as date and time of detection.

Receivers deployed in an estuarine or riverine environment were attached to concrete blocks and secured to a dock, piling, or other permanent structure in the water body. Receivers deployed in the Gulf required an anchor/buoy assembly to secure the receiver in open Gulf waters. The buoy/anchor system used in the Gulf consisted of a 14-inch diameter buoy attached to galvanized steel ¼ inch cable wire that connects to a 130-pound anchor block. The receivers were attached to an aluminum bar located just beneath the buoy (Figure 3).

Thirteen Vemco® receivers were placed in various locations in the Choctawhatchee Bay, Gulf of Mexico and Santa Rosa Sound near Eglin’s mission areas in order to track the tagged sturgeons’ movements (Figure 4). The receivers in the Gulf were placed in three locations off Eglin’s property on Santa Rosa Island (SRI), with arrays of three receivers at each location. Each array consisted of receivers aligned perpendicular to the shoreline, and located at 500, 1,000, and 1,500 meters from shore. It was thought that the receivers could detect transmissions emitted within a 500 meter radius therefore this configuration would allow coverage of over one nautical mile, thereby encompassing the entire seaward range of critical habitat. Two receiver arrays were placed in critical habitat areas offshore of SRI, while one array was placed east of the Destin Pass. Three receivers were placed in the Santa Rosa Sound off of SRI and one receiver was placed near the Intercoastal Waterway in Choctawhatchee Bay. This arrangement allowed Eglin to determine sturgeon movements in estuarine areas before entering the Gulf, where they traveled once they entered the Gulf, and whether or not they remained in the vicinity throughout the winter. The receivers were left in place from October 2008 to April 2009.

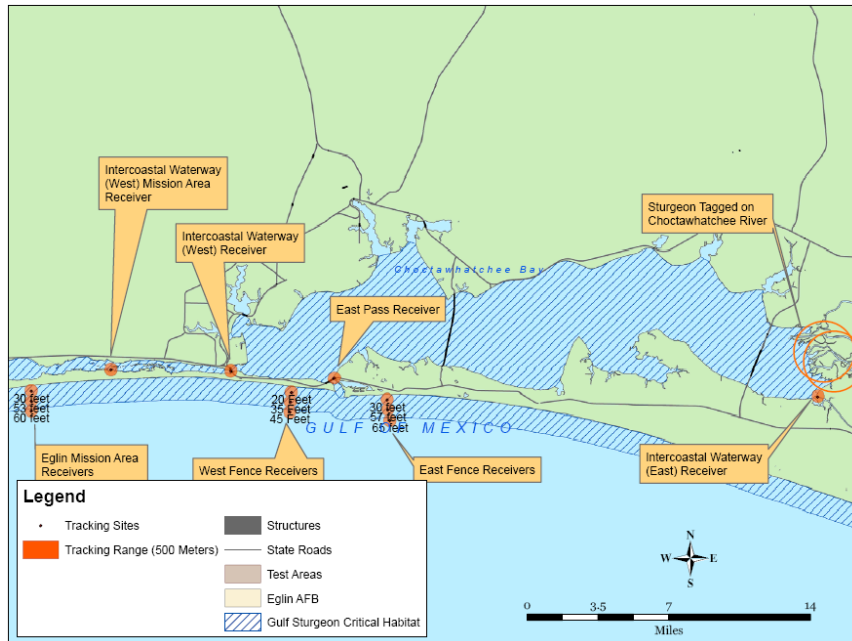


Figure 4. Receiver Locations for the 2008 Pilot Study

III. Summary of Results for 2008 Pilot Study

Of the 40 tagged sturgeon, 26 were detected either by the receivers or by hand-held hydrophone tracking conducted by the USFWS. Sturgeon were found to move through the Santa Rosa Sound, and both east and west in the Gulf after passing through the Destin Pass. The most shoreward of the receivers (approximately 500 meters from the shoreline) recorded the majority of transmissions (approximately 82 percent), indicating that Gulf sturgeon have a strong tendency to travel close to the shore while in the Gulf of Mexico. The middle receivers recorded 18 percent of the detections, while the receivers located furthest from shore recorded less than 1 percent. Of the three receivers located 1,500 meters from shore, only one recorded the occurrence of a tagged sturgeon, and that receiver had 4 detections compared to approximately 4,000 detections from the shoreward receivers. In addition, there were few sturgeon transmissions detected from the middle of December through the beginning of March, suggesting that the sturgeon moved away from the area near Eglin's SRI property during this time. These results represented new and valuable information for determining mission avoidance zones, in terms of season and distance from shore. The last recorded Gulf sturgeon occurrence in the Gulf of Mexico was on March 13, 2009, indicating most sturgeon had moved back into the river systems by that time.

IV. 2008 Pilot Study Conclusions

Approximately 99 percent of all sturgeon activity near SRI occurred within 1,000 meters of the shoreline, in depths of 13.7 meters (45 feet) or less. In other words, the sturgeon are only utilizing about half (0.54 NM) of the seaward extent of their critical habitat area in the Gulf of Mexico near Eglin AFB.

There were some lessons learned while conducting this Pilot Study. After being in the Gulf for 6 months, the galvanized steel cable wiring had some corrosion problems and cleaning the receivers of barnacle growth proved to be difficult.

V. Methodology for FY 2009 Legacy Study

Based on the results of the 2008 Pilot Study, some adjustments were made for the 2009 Legacy Study. Stainless steel cable was substituted for the galvanized steel to prevent corrosion due to submersion in the marine environment for an extended period of time. Additionally, the

receivers were wrapped with copper foil to protect them from marine growth such as barnacles (Figure 5).



Figure 5. Updated Anchor/buoy assembly

In order to increase the robustness of the study, transmitters were implanted in 40 additional Gulf sturgeon from the Yellow, Blackwater, and Escambia Rivers (also referred to as the Pensacola Bay System Rivers). Twelve sturgeon were tagged in the Yellow River, 25 were tagged in the Blackwater River, and 3 were tagged in the Escambia River. It has generally been thought, but not necessarily proven, that Gulf sturgeon have high fidelity in returning to the same river system each spring. Tagging

fish from different systems allowed this hypothesis to be tested. Also, including the three additional rivers enabled the study to cover all systems in the vicinity of Eglin AFB.

Another significant change in the scope of the 2009 Legacy Study was receiver placement and configuration. Twenty-one receivers were utilized for this study, as opposed to only thirteen in the 2008 Pilot Study. Receivers were placed at the same locations in the Gulf of Mexico, off Eglin's SRI property and east of Destin Pass. However, based on results of the 2008 Pilot Study, only two receivers per array were deployed. The outer receiver location (1,500 meters from shore) was omitted because of the low sturgeon occurrence previously documented. This allowed for a wider coverage of Gulf of Mexico critical habitat areas to be monitored which would provide a more detailed picture of sturgeon movement. In addition to the previous Gulf of Mexico and Santa Rosa Sound locations, receivers were placed in the Gulf east and west of Pensacola Pass and near Perdido Key, Alabama. They were also deployed near the mouths of the Yellow, Blackwater, and Escambia Rivers, as well as the Pensacola Bay (Figure 6). Perdido Pass was included because USFWS personnel suspect that this is a popular congregating area for Gulf sturgeon. The receivers were therefore set up to detect sturgeon movement from Destin, Florida to Perdido Key, Alabama, in riverine, estuarine, and marine environments. This configuration allowed data collection in areas heavily utilized by the DoD for testing and training activities. These receivers were able to detect Gulf sturgeon tagged by Eglin in 2008 and 2009, as well as sturgeon tagged by other researchers utilizing the same acoustic technology.

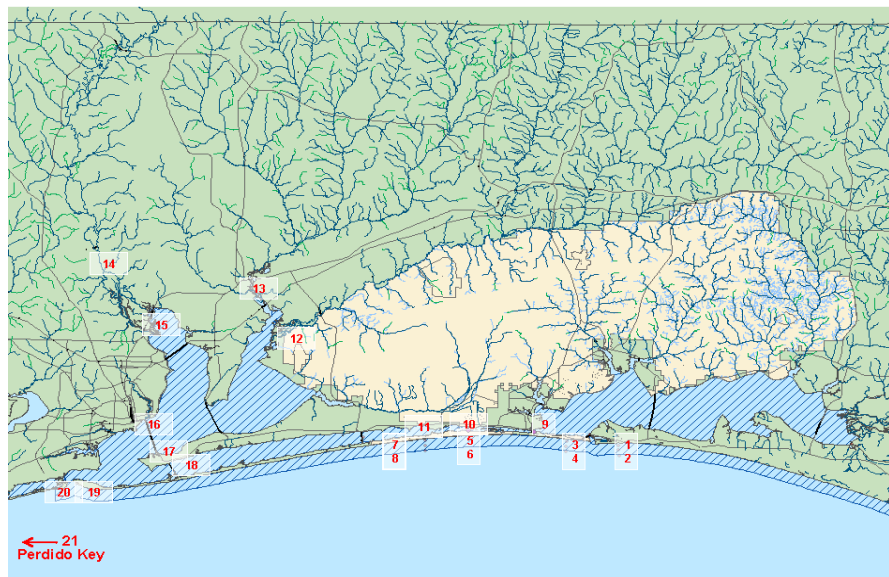


Figure 6. Original Locations of Receivers for 2009 Legacy Study

VI. Results and Discussion

The results of the 2009 Legacy Study are divided into subsections that provide detailed information about: 1) deploying, downloading, and collecting the receivers, 2) the numbers of detections received per receiver and per sturgeon, 3) the river origins of the

detected sturgeon, 4) their movement and distribution patterns in the Gulf of Mexico, 5) river fidelity, and 6) a comparison of weather data with detection rates of receivers in the marine environment.

1. Deploying, Downloading, and Collecting Receivers

Table 2 lists the GPS coordinates of where the receivers were deployed. The maps above only show the general locations of each receiver.

Table 2. Receiver IDs and Locations of Deployment

Receiver ID	Receiver Serial #	Receiver Location	Latitude	Longitude
1	106138	Gulf of Mexico Destin Inshore	N30° 22.748'	W086° 29.549'
2	106142	Gulf of Mexico Destin Offshore	N30° 22.306'	W086° 29.560'
3	106136	Gulf of Mexico A-3 Inshore	N30° 23.072'	W086° 32.794'
4	106143	Gulf of Mexico A-3 Offshore	N30° 22.635'	W086° 32.802'
5	106140	Gulf of Mexico A-11 Inshore	N30° 23.539'	W086° 42.799'
6	106135	Gulf of Mexico A-11 Offshore	N30° 23.331'	W086° 42.760'
7	106125	Gulf of Mexico A-18 Inshore	N30° 22.756'	W086° 50.695'
8	106129	Gulf of Mexico A-18 Offshore	N30° 22.461'	W086° 50.656'
9	106131	Santa Rosa Sound Brooks Bridge	N30° 23.931'	W086° 36.108'
10	106124	Santa Rosa Sound A-10	N30° 24.081'	W086° 42.011'
11	106123	Santa Rosa Sound A-15	N30° 23.533'	W086° 48.481'
12	106133	Yellow River	N30° 33.478'	W086° 58.919'
13	106126	Black-water River	N30° 37.467'	W087° 02.081'
14	106137	Escambia River	N30° 40.200'	W087° 15.975'
15	106128	Santa Rosa Sound EPA Lab*	N30° 20.243'	W087° 09.396'
16	106134	Pensacola Bay North	N30° 24.884'	W087° 11.522'
17	106127	Pensacola Bay South	N30° 22.350'	W087° 10.667'
18	106141	Santa Rosa Sound Bob Sikes Bridge	N30° 21.004'	W087° 10.516'
19	106132	Gulf of Mexico Pensacola Pass East	N30° 18.900'	W087° 17.225'
20	106130	Gulf of Mexico Pensacola Pass West	N30° 18.571'	W087° 20.403'
21	106139	Gulf of Mexico Perdido Key, AL	N30° 15.745'	W087° 34.815'

*Receiver 15 was originally located in a southern portion of Escambia River, but there were no detections at that location so it was relocated to the EPA Lab in Gulf Breeze in the Santa Rosa Sound on 2/9/2010.

Table 3 shows the dates that each receiver was deployed, downloaded, and the total number of days each receiver was deployed and collected data for this study. The receivers are also categorized based on the areas where they were deployed so the discussion can refer to groups of receivers within a general location. The categories are as follows:

- E GOM – area in the Gulf east of Eglin’s property and east of the Destin Pass
- EGLIN – area within Eglin’s Gulf ranges
- W GOM – area west of Eglin’s property near the Pensacola Pass and Perdido Key
- SRS – Santa Rosa Sound
- P-COLA – Pensacola Bay
- RIVER – Yellow, Blackwater, or Escambia Rivers (i.e., Pensacola Bay System Rivers)

Table 3. Deployment, Download, and Collection Dates and Total Number of Deployment Days for Each Receiver

Receiver ID	Date Deployed	Download #1	Download #2	Download #3	Date Collected	Final Download	# of Days Deployed	
E GOM	1	10/13/2009	11/20/2009	1/6/2010	3/4/2010	4/19/2010	4/20/2010	189
	2	10/13/2009	11/20/2009	1/6/2010	3/4/2010	4/19/2010	4/20/2010	189
EGLIN	3	10/13/2009	11/20/2009	1/6/2010		4/19/2010	4/20/2010	189
	4	10/13/2009	11/20/2009	1/6/2010	3/4/2010	4/19/2010	4/20/2010	189
	5	10/19/2009	11/20/2009	1/6/2010		4/19/2010	4/20/2010	183
	6	10/19/2009	11/20/2009	1/6/2010		4/19/2010	4/20/2010	183
	7	10/19/2009	Came ashore during Tropical Storm IDA in November 2009 – No Data					
	8	10/19/2009	4/19/2010			4/19/2010	4/20/2010	183
SRS	9	10/6/2009	11/6/2009	1/13/2010	3/1/2010	5/18/2010	5/18/2010	225
	10	9/28/2009	11/6/2009	3/1/2010		5/18/2010	5/18/2010	233
	11	9/28/2009	11/6/2009	3/1/2010		5/18/2010	5/18/2010	233
	15	2/9/2010*	5/18/2010			5/18/2010	5/20/2010	99
	18	10/12/2009	Reported missing on 12/1/2009 – No Data					
RIVER	12	9/25/2009	12/1/2009	1/15/2010	3/11/2010		5/19/2010	237
	13	9/25/2009	12/1/2009	1/15/2010	3/11/2010	5/19/2010	5/19/2010	237
	14	9/29/2009	12/1/2009	1/15/2010		5/19/2010	5/19/2010	237
P-COLA	16	10/8/2009	Reported missing on 12/1/2009 – No Data					
	17	10/7/2009	12/1/2009	1/15/2010	3/11/2010	5/19/2010	5/19/2010	225
W GOM	19	10/28/2009	1/4/2010	2/18/2010		5/10/2010	5/12/2010	195
	20	10/28/2009	1/4/2010	2/18/2010		5/10/2010	5/12/2010	195
	21	11/11/2009	1/4/2010	2/18/2010		Gone**	2/18/2010**	100

E GOM = Eastern Gulf of Mexico; SRS = Santa Rosa Sound; P-COLA = Pensacola Bay; W GOM = Western Gulf of Mexico

*Receiver 15 was originally located in a southern portion of Escambia River, but there were no detections at that location so it was relocated to the EPA Lab in Gulf Breeze in the Santa Rosa Sound on 2/9/2010.

**Receiver 21 was missing during the receiver collection effort on 5/10/2010.

There were issues with several receivers during the course of the project (Tables 2 and 3). Receiver 7 washed ashore during a tropical storm in November 2009 and was not re-deployed. Receivers 16 and 18 were missing during their first download attempt on 12/1/2009 and neither of them was recovered. Receiver 15 was located on a distributary of the Escambia River, rather than the main channel, due to a lack of suitable, accessible locations on the main channel. No detections occurred at this location for several months, which indicated that no sturgeon passed by that area during their outmigration from the Escambia River. It was decided that this receiver would better serve its purposes by relocating it to another location within the Santa Rosa Sound, a suspected transitional area for sturgeon. This relocation occurred on 2/9/2010. Finally receiver 21 was missing during the receiver collection effort on 5/10/2010 for the western Gulf of Mexico receivers at the end of the study, so the latest data collected on that receiver were from the download on 2/18/2010. The following map (Figure 7) shows the final locations of the remaining receivers that were included in the data analysis for the 2009 Legacy Study.

Receiver 12 was left in the Yellow River to continue monitoring sturgeon presence and movement through that system during the summer. The other RIVER receivers (13 and 14) had to be collected to find either a better location (13) or to be better secured at the location (14).

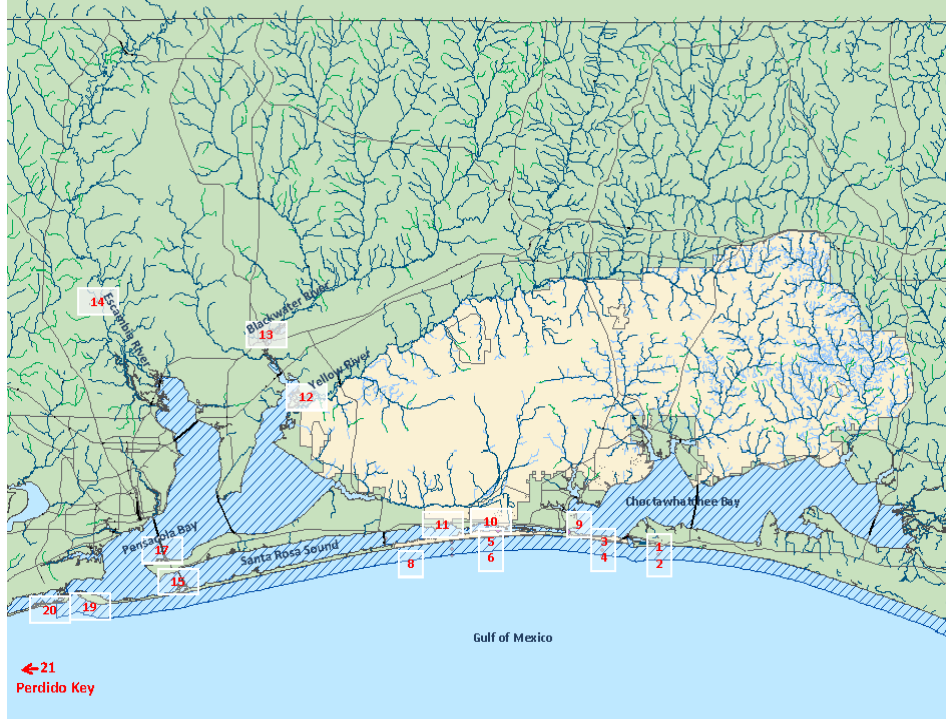


Figure 7. Final Locations of Receivers for FY 2009 Legacy Study

2. Number of Detections

Eglin’s receivers collected 161,569 detections from 86 different tagged sturgeon while they were deployed from late September 2009 to mid May 2010. The river origins of these sturgeon will be discussed in the next section. This section will only look at total detections on each receiver.

Table 4 shows the numbers of detections each receiver collected per month. Cells contain a dash (-) indicate that the receiver was not deployed during that month and therefore was not available to collect data.

Table 4. Number of Detections at Each Receiver

Receiver ID		Sept 2009	Oct 2009	Nov 2009	Dec 2009	Jan 2010	Feb 2010	Mar 2010	Apr 2010	May 2010	TOTAL
E GOM	1	-	0	148	2,008	4,650	407	1,160	83	-	8,456
	2	-	0	22	433	336	44	29	18	-	882
EGLIN	3	-	0	538	25,112	12,533	8,977	7,487	93	-	54,740
	4	-	0	16	5,778	7,588	8,605	748	0	-	22,735
	5	-	0	127	708	587	710	885	74	-	3,091
	6	-	0	0	94	46	24	132	22	-	318
	8	-	0	36	94	95	71	73	57	-	426
SRS	9	0	25	3,087	3,812	393	2	240	600	0	8,159
	10	0	1	218	212	2	0	92	15	0	540
	11	0	13	113	972	255	33	248	9	0	1,643
	15	-	-	-	-	-	34	547	359	0	940
RIVER	12	503	2,551	0	0	0	0	948	2,468	1,613	8,083
	13	0	1,562	0	0	0	0	0	874	1,365	3,801
	14	98	13,598	0	0	0	0	0	47	53	13,796

Receiver ID		Sept 2009	Oct 2009	Nov 2009	Dec 2009	Jan 2010	Feb 2010	Mar 2010	Apr 2010	May 2010	TOTAL
P-COLA	17	-	1,079	3,927	186	2	0	643	126	0	5,963
W GOM	19	-	0	188	287	798	633	13,303	1,110	8	17,427
	20	-	3	2,580	563	874	483	2,249	368	0	7,120
	21	-	-	612	2,036	735	66	-	-	-	3,449
TOTALS		601	18,832	11,612	42,295	28,894	20,089	29,884	6,323	3,039	161,569

Table 5 shows the number of individual sturgeon that were detected at each receiver each month. Note that the “TOTAL” column is not the sum of the row as some of the same sturgeon were detected over multiple months. This value only represents the number of sturgeon each respective receiver detected throughout the entire course of the project. The river origins of the sturgeon will be discussed in the next section.

Table 5. Number of Sturgeon Detected at Each Receiver

Receiver ID		Sept 2009	Oct 2009	Nov 2009	Dec 2009	Jan 2010	Feb 2010	Mar 2010	Apr 2010	May 2010	TOTAL
E GOM	1	-	0	4	16	9	5	14	7	-	29
	2	-	0	2	12	8	2	3	1	-	20
EGLIN	3	-	0	11	21	11	8	12	3	-	37
	4	-	0	3	15	9	6	8	0	-	24
	5	-	0	8	15	9	5	11	5	-	30
	6	-	0	0	5	2	2	5	3	-	15
	8	-	0	1	6	4	3	6	2	-	20
	9	0	1	17	16	6	1	3	5	0	28
SRS	10	0	1	5	8	2	0	3	3	0	15
	11	0	2	4	8	3	1	4	2	0	18
	15	-	-	-	-	-	2	15	5	0	19
	12	1	14	0	0	0	0	12	18	8	32
RIVER	13	0	25	0	0	0	0	0	4	9	28
	14	3	6	0	0	0	0	0	5	2	9
	P-COLA	17	-	17	20	5	1	0	11	8	0
W GOM	19	-	0	12	14	16	10	25	11	1	45
	20	-	1	22	15	13	9	22	14	0	45
	21	-	-	10	14	15	4	-	-	-	28
TOTALS		4	45	58	62	38	27	57	49	18	86

In order to determine which locations are used as congregating areas and which locations are used as transit areas, the graph below (Figure 8) shows the total number of detections compared to the total number of sturgeon detected at each receiver over the course of the study.

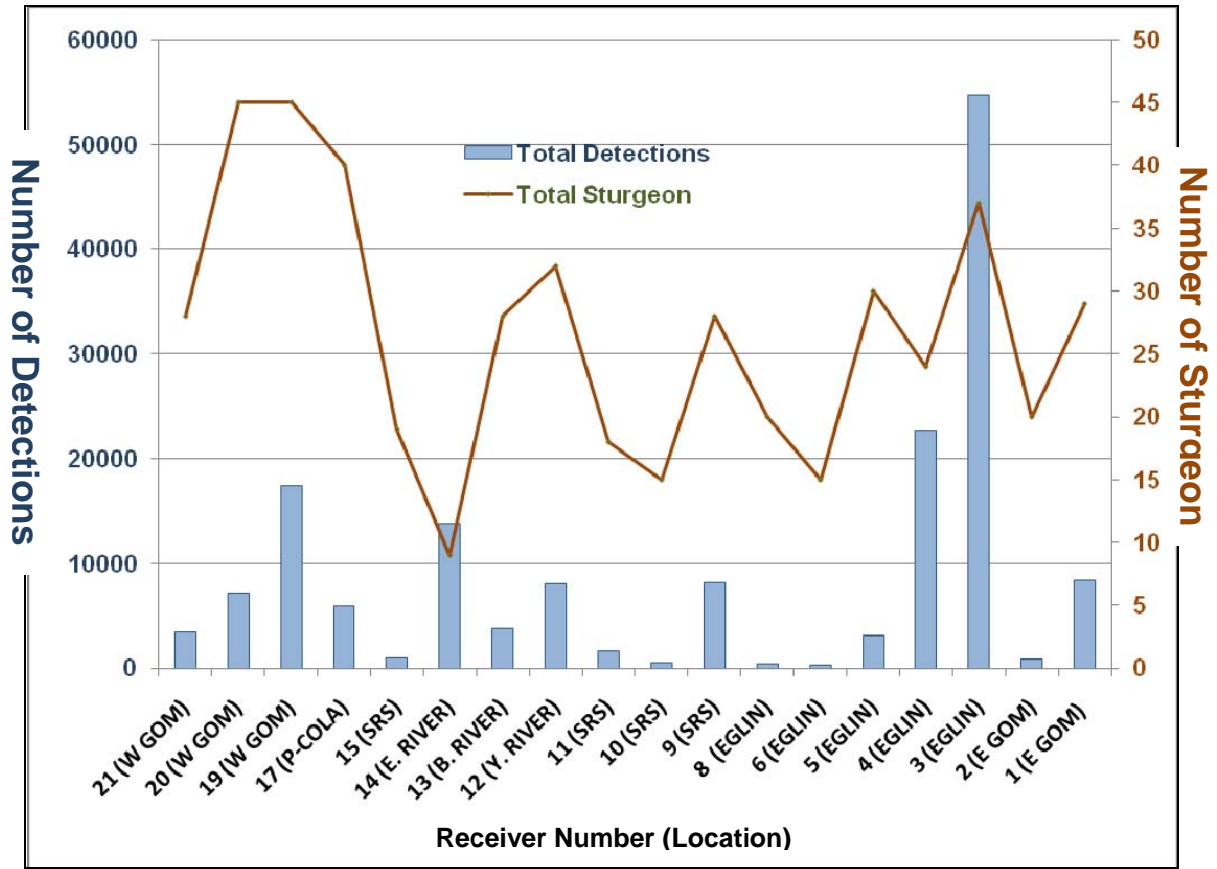


Figure 8. Total Detections vs. Total Number of Sturgeon Detected

Receivers with high numbers of sturgeon but relatively low numbers of detections, may indicate locations where sturgeon transit through but do not congregate (Figure 8). For example, there is a comparatively high number of sturgeon for the number of detections at the W GOM receivers (19, 20, & 21); this may be an area that sturgeon passed through on their way further west in the fall. Alternately, EGLIN receivers (3, 4, 5, 6, & 8), specifically receiver 3, show both higher numbers of detections and higher numbers of sturgeon, which suggests that the sturgeon lingered in these areas longer than they did in the W GOM.

Calculation of the ratio of total detections to total number of sturgeon detected yielded an average number of detections for each sturgeon at each receiver (Table 6 and Figure 9). The average ratio for this study was approximately 340 detections per sturgeon. Two of the EGLIN receivers (specifically 3 and 4) have ratios that are well above the average, indicating that these may be areas that are highly utilized by Gulf sturgeon for an extended period of time. Receiver 14 also had a ratio well above the average because it received an unusually high number of detections from one individual that remained in the area for over two weeks in October before it exited the river. This individual alone accounted for 13,516 detections, which likely skewed the results for this receiver. The next section investigates this issue further by looking at the river origins of these sturgeon and how differing ping intervals for the tags inserted into the sturgeon may have an impact on these results.

Table 6. Calculation of Ratio of Total Detections / Total Sturgeon per Receiver

Receiver ID		Ratio of Total Detections/Total Sturgeon
E GOM	1	8,456/29 = 292
	2	882/20 = 44
EGLIN	3	54,740/37 = 1,479
	4	22,735/24 = 947
	5	3,091/30 = 103
	6	318/15 = 21
	8	426/20 = 21
	9	8,159/28 = 291
SRS	10	540/15 = 36
	11	1,643/18 = 91
	15	940/19 = 49
	12	8,083/32 = 253
RIVER	13	3,801/28 = 136
	14	13,796/9 = 1,533
	17	5,963/40 = 149
W GOM	19	17,427/45 = 387
	20	7,120/45 = 158
	21	3,449/28 = 123

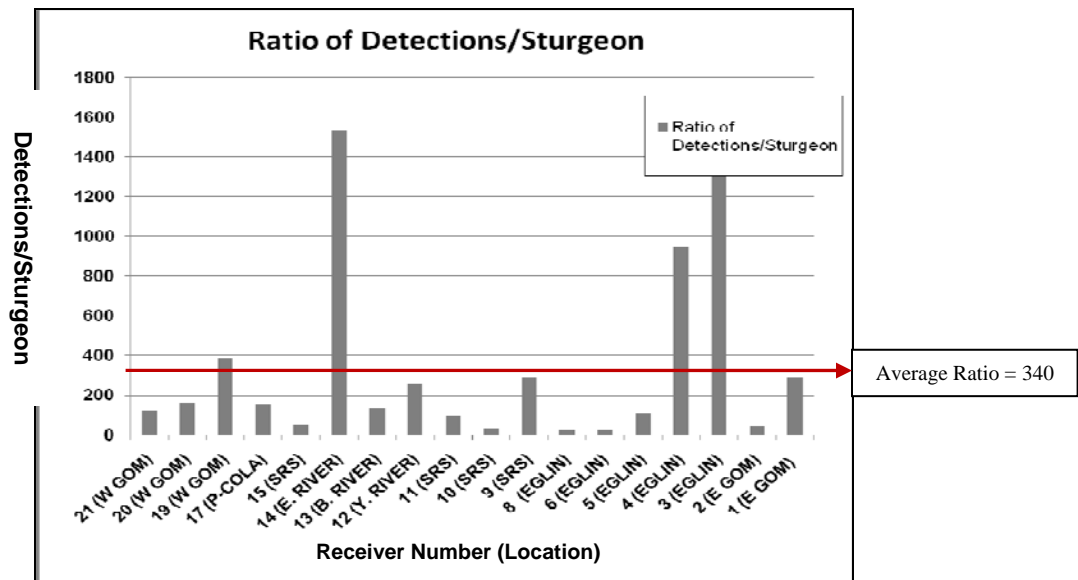


Figure 9. Graph Detections/Sturgeon Ratio for all Receivers

The following series of maps (Figures 10–17) shows how detections were distributed across the study area over the course of the project. The number of detections are shown as ranges and color coded on each map as described in Table 7. Each map is also accompanied with a table (Tables 8–15) showing the exact numbers of detections and sturgeon detected at each location. Detections received and number of sturgeon detected each month are totaled. The number of sturgeon detected is not the sum of sturgeon

detected on each receiver since some sturgeon travel to multiple receiver locations during the month.

Table 7. Detection Ranges as Depicted on Maps

Circle Color	Corresponding Number of Detections
White	1 to 100
Purple	101 to 500
Blue	501 to 1,000
Green	1,001 to 5,000
Yellow	5,001 to 10,000
Orange	10,001 to 20,000
Red	Over 20,000

Figure 10 shows that most of the sturgeon are still in their respective river systems in October. Although only 3 sturgeon were tagged in the Escambia River, receiver 14 had detections from 6 different sturgeon in October. Similarly, while only 12 sturgeon were tagged in the Yellow River, receiver 12 had detections from 14 different sturgeon. October detections on the P-COLA and SRS receivers indicate that some sturgeon have either begun migrating to the Gulf or they utilized estuarine habitat in addition to riverine habitat during the summer or fall.

Table 8. October 2009 Results

Area (Receiver #)	Detections	Sturgeon
Escambia River (14)	13,596	6
Blackwater River (13)	1,562	25
Yellow River (12)	2,551	14
P-COLA (17)	1,079	17
SRS (9, 10, & 11)	38	2
TOTAL	18,832	45

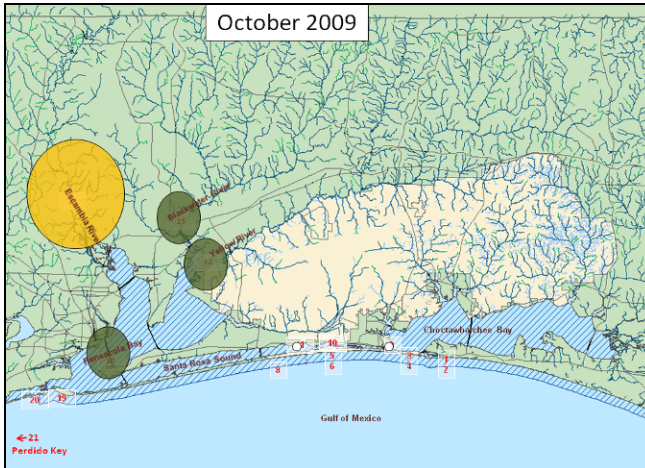


Figure 10. Detections during October 2009

By November, there were no detections at the RIVER receivers and W GOM, EGLIN, and E GOM receivers have all begun to detect sturgeon (Figure 11, Table 9). Pensacola Bay and Santa Rosa Sound also have high sturgeon activity this month as the remaining sturgeon continue migrating to Gulf waters.

Table 9. November 2009 Results

Area (Receiver #)	Detections	Sturgeon
E GOM (1&2)	170	4
EGLIN (3, 4, 5, 6, & 8)	717	11
SRS (9, 10, & 11)	3,418	19
P-COLA (17)	3,927	20
W GOM (19, 20, & 21)	3,380	27
TOTAL	11,612	58

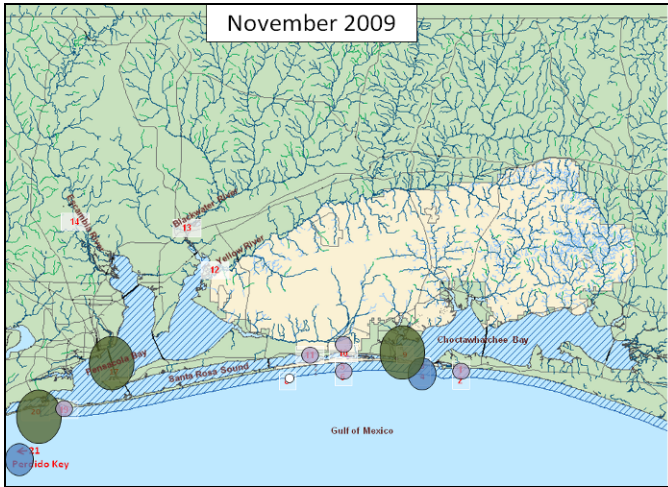


Figure 11. Detections during November 2009

December marks the beginning of high sturgeon activity in the Gulf, with receivers 3 and 4 in Eglin’s Gulf ranges having the highest detections and numbers of sturgeon detected (Figure 12, Table 10). Although the W GOM receivers have detected more sturgeon than EGLIN receivers, the numbers of detections are significantly lower (Table 10). Detection/sturgeon ratios (Table 6) suggests that the sturgeon detected on the W GOM receivers only pass through the area, while the sturgeon detected on EGLIN receivers tend to linger in this area for longer periods of time.

Table 10. December 2009 Results

Area (Receiver #)	Detections	Sturgeon
E GOM (1&2)	2,441	16
EGLIN (3, 4, 5, 6, & 8)	31,786	25
SRS (9, 10, & 11)	4,996	19
P-COLA (17)	186	5
W GOM (19, 20, & 21)	2,886	28
TOTAL	42,295	62

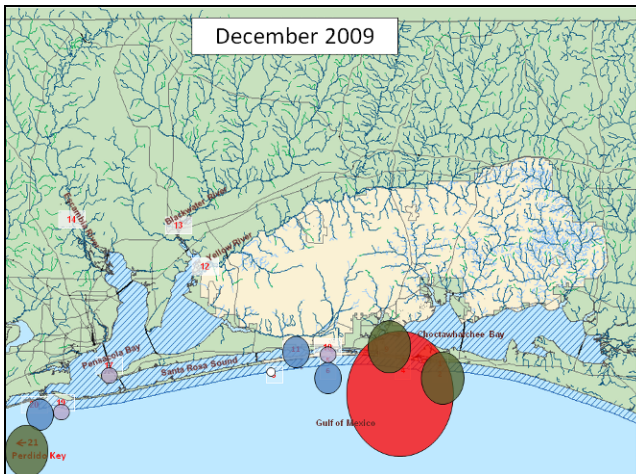


Figure 12. Detections during December 2009

The same trend continues through January (Figure 13, Table 11). It is possible that the sturgeon detected on the W GOM receivers are heading further west for the winter, however the western extent of their Gulf migration remains unknown. This level of activity is different from the 2008 Pilot Study which showed a decline in the level of sturgeon activity in this part of the Gulf beginning mid-December and lasting through early March.

Table 11. January 2010 Results

Area (Receiver #)	Detections	Sturgeon
E GOM (1&2)	4,986	11
EGLIN (3, 4, 5, 6, & 8)	20,849	14
SRS (9, 10, & 11)	650	8
P-COLA (17)	2	1
W GOM (19, 20, & 21)	2,407	25
TOTAL	28,894	38

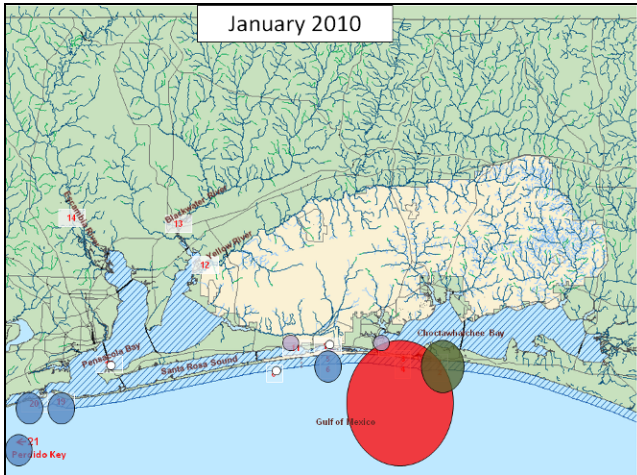


Figure 13. Detections during January 2010

February showed a decline in detections and in the number of sturgeon detected (Figure 14, Table 12). At this time, the sturgeon have likely arrived at the destinations of their winter migration, which extend to areas in the Gulf where there were no receivers. The same trends in the W GOM receivers continues this month, with more sturgeon detected but much lower numbers of detections on these receivers than on EGLIN receivers. Receiver 21 at Perdido Key was missing during the final collection and download for the season; the last detection on that receiver occurred on 2/13/2010. The newly deployed receiver 15 is now included as part of the SRS receivers.

Table 12. February 2010 Results

Area (Receiver #)	Detections	Sturgeon
E GOM (1&2)	451	5
EGLIN (3, 4, 5, 6, & 8)	18,387	7
SRS (9, 10, 11, & 15)	69	4
W GOM (19, 20, & 21)	1,182	20
TOTAL	20,089	27

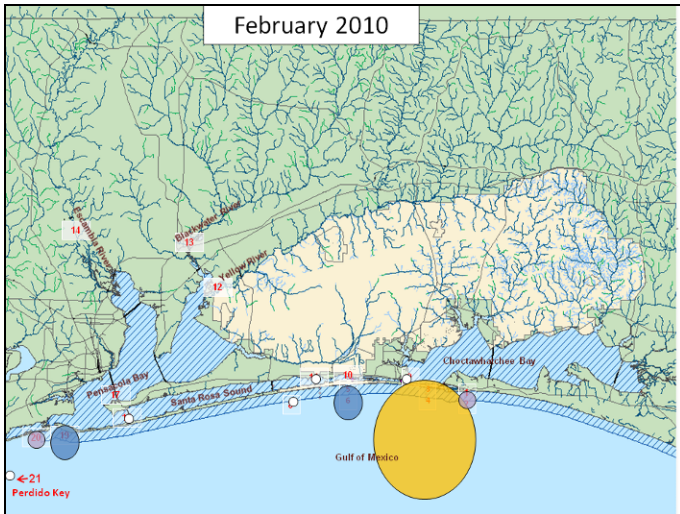


Figure 14. Detections during February 2010

Beginning in March, sturgeon detections start to increase on the W GOM and E GOM receivers near the passes into Pensacola Bay and Choctawhatchee Bay, and also increase for the SRS receivers which are located between the two bays, indicating the beginning of migration back into the rivers for the spring and summer months. During this same period, sturgeon activity on EGLIN receivers has begun to decrease. March is the first

month since October with detections at any of the RIVER receivers, specifically in the Yellow River.

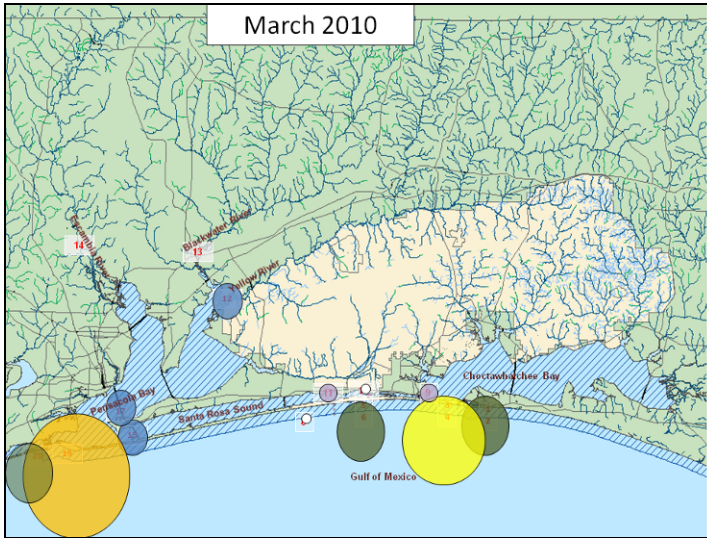


Figure 15. Detections during March 2010

Table 13. March 2010 Results

Area (Receiver #)	Detections	Sturgeon
E GOM (1&2)	1,189	13
EGLIN (3, 4, 5, 6, & 8)	9,322	15
SRS (9, 10, 11, & 15)	1,127	18
W GOM (19, 20, & 21)	16,652	36
P-COLA (17)	643	11
Yellow River (12)	948	12
TOTAL	29,884	57

In April, detections and numbers of sturgeon were up at all of the RIVER receivers and down at the GOM, P-COLA, EGLIN, and SRS receivers (Figure 16, Table 14). Based on the results from the 2008 Pilot Study which indicated that the last sturgeon were detected in the Gulf in early March, all E GOM and EGLIN receivers were collected on 4/19/2010 and downloaded the following day, therefore these receivers did not get a full month's worth of detections. When the receivers were downloaded, the data showed that one sturgeon had been detected the day before the receivers were collected, and another one was detected a week before. This suggests that sturgeon activity in the Gulf can continue as late as April, even while others have already returned to the rivers. Based on this information, the W GOM receivers were left a little longer in order to ensure that sturgeon detections in the Gulf were not missed. Furthermore, all other receivers were downloaded before they were collected from the field to determine when the last detection occurred and if the receiver was ready to be pulled for the season.

Table 14. April 2010 Results

Area (Receiver #)	Detections	Sturgeon
E GOM (1&2)	101	8
EGLIN (3, 4, 5, 6, & 8)	246	6
SRS (9, 10, 11 & 15)	983	9
W GOM (19, 20, & 21)	1,478	15
P-COLA (17)	126	10
Yellow River (12)	2,468	19
Blackwater River (13)	874	4
Escambia River (14)	47	5
TOTAL	6,323	49

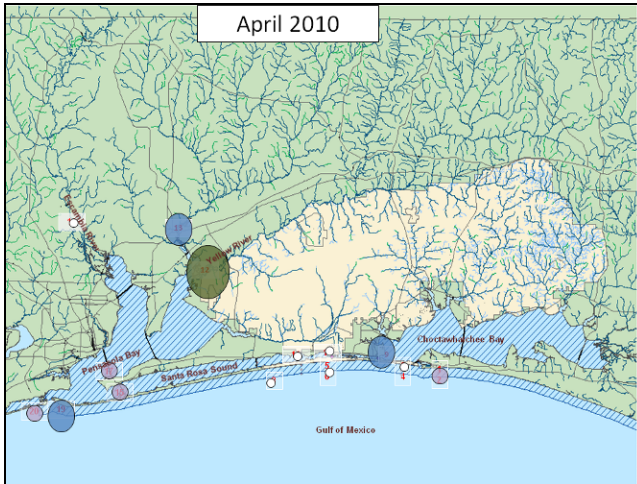


Figure 16. Detections during April 2010

The remaining GOM, SRS, and P-COLA receivers were collected in mid-May (refer to Table 3) therefore data were not collected for a full month. There were no detections on the SRS and P-COLA receivers during this month (Figure 17, Table 15). One fish was still detected on one of the W GOM receivers the day before it was collected. It was the same sturgeon that was last detected on the EGLIN receivers.

Table 15. May 2010 Results

Area (Receiver #)	Detections	Sturgeon
W GOM (19, 20, & 21)	8	1
Yellow River (12)	1,613	8
Blackwater River (13)	1,365	9
Escambia River (14)	53	2
TOTAL	3,039	18

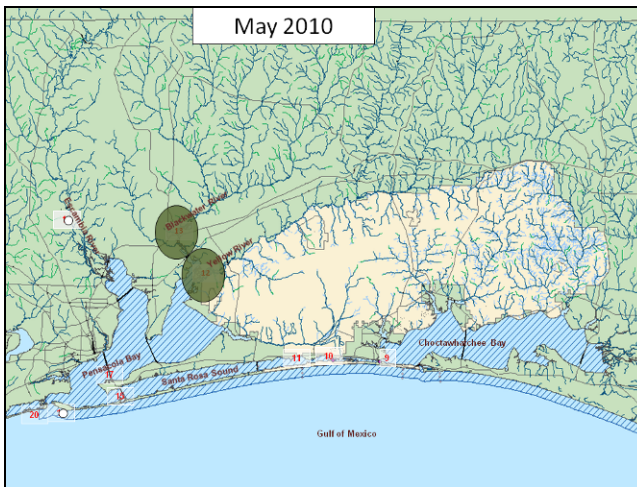


Figure 17. Detections during May 2010

Figures 18 and 19 illustrate the number of detections and number of sturgeon detected.

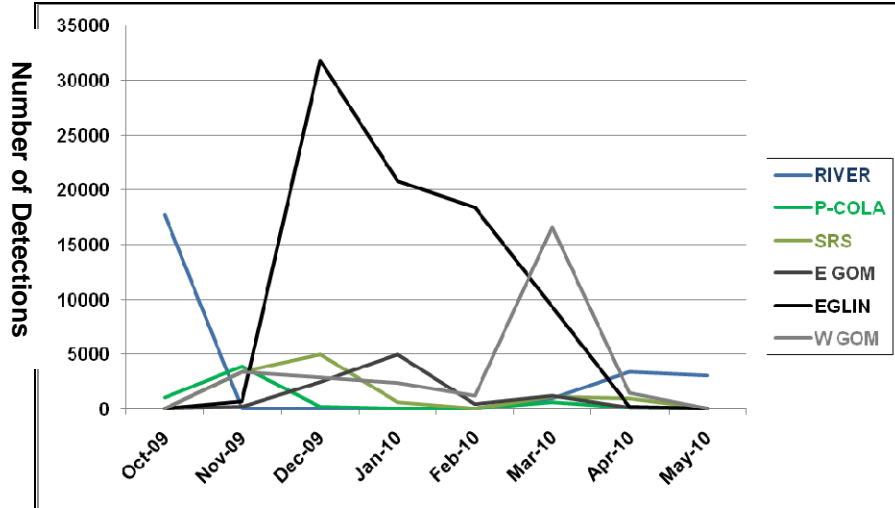


Figure 18. Number of Detections per Location per Month

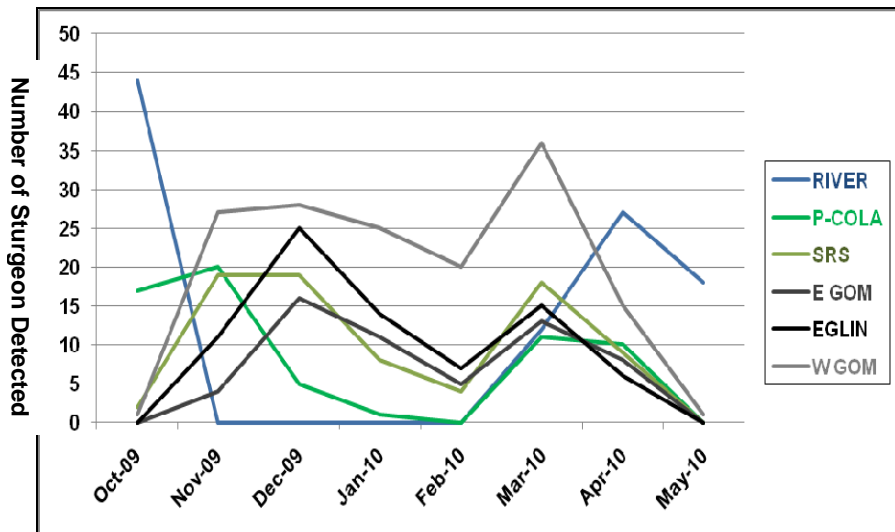


Figure 19. Number of Sturgeon Detected per Location per Month

As the two figures above indicate, the EGLIN receivers begin experiencing some sturgeon activity in October with peak activity occurring in December. By January, this level of activity has declined. February shows a moderate decrease in detections within Eglin’s Gulf ranges, however the number of sturgeon detected declined significantly for all receivers in the Gulf. The W GOM and SRS receivers both show an increase in activity (both in detections and numbers of sturgeon) during March as the sturgeon are heading back to the rivers and begin inhabiting the estuarine areas for a brief time. By April, the RIVER receivers show a peak in the number of sturgeon detected with a relatively modest increase in detections indicating that the sturgeon are entering the rivers and immediately heading upstream for the spring and summer months. In May, no more

sturgeon are detected on the SRS or P-COLA receivers, suggesting their spring migration to the rivers is complete.

3. River Origins of Detected Sturgeon

This section examines the numbers of sturgeon and detections as related to the different organizations that tagged the fish and the river systems in which the fish were tagged, as these variables may contribute to differences in movement patterns and distributions in the Gulf during the winter.

Table 16 lists the details of all the sturgeon tagged by Eglin for the 2009-2010 Legacy Study. Refer to Table 1 for tag IDs of sturgeon tagged in the Choctawhatchee River in 2008.

Table 16. Information on Sturgeon Tagged for the 2009-2010 Legacy Study

Vemco® Tag ID	Location Collected	Fork length (inches)	Weight (lbs)	Date Tagged
61006	Blackwater River	60.50	55.25	10/2/2009
61007	Blackwater River	55.75	49.00	9/30/2009
61008*	Escambia River	70.00	118.50	9/30/2009
61009	Blackwater River	59.25	58.00	9/30/2009
61010*	Blackwater River	73.00	138.00	10/2/2009
61011*	Blackwater River	63.50	84.75	9/30/2009
61012	Blackwater River	61.00	64.00	10/2/2009
61013	Blackwater River	68.00	97.50	10/2/2009
61014	Blackwater River	55.50	51.25	10/2/2009
61015*	Escambia River	63.00	83.00	9/30/2009
61016*	Yellow River	62.75	63.50	9/18/2009
61017	Yellow River	56.00	52.00	9/11/2009
61018*	Blackwater River	70.00	99.50	9/21/2009
61019	Yellow River	50.00	41.00	9/18/2009
61020*	Yellow River	74.50	118.00	9/18/2009
61021	Yellow River	67.50	94.00	9/18/2009
61022	Yellow River	58.00	52.50	9/18/2009
61023	Yellow River	57.25	45.50	9/18/2009
61024	Yellow River	58.50	63.00	9/11/2009
61025	Yellow River	55.00	47.50	9/11/2009
61026	Yellow River	51.00	41.00	9/11/2009
61027	Yellow River	58.00	53.50	9/11/2009
61028*	Blackwater River	74.00	132.75	9/21/2009
61029*	Blackwater River	69.00	109.50	9/21/2009
61030	Blackwater River	55.50	53.50	9/21/2009
61031	Blackwater River	67.50	105.00	9/21/2009
61032	Blackwater River	52.00	44.50	10/2/2009
61033	Escambia River	63.00	79.50	9/30/2009
61034*	Blackwater River	73.50	127.50	9/22/2009
61035*	Blackwater River	65.50	70.25	9/22/2009
61036	Yellow River	48.50	31.25	9/29/2009
61037	Blackwater River	53.75	52.50	9/21/2009
61038*	Blackwater River	72.00	110.00	9/21/2009
61039*	Blackwater River	69.00	115.50	9/21/2009
61040*	Blackwater River	64.50	85.25	9/21/2009
61041	Blackwater River	57.50	52.50	10/2/2009
61042*	Blackwater River	71.00	127.00	10/2/2009

Vemco® Tag ID	Location Collected	Fork length (inches)	Weight (lbs)	Date Tagged
61043	Blackwater River	49.00	31.25	10/2/2009
61044*	Blackwater River	64.75	84.00	10/2/2009
61045*	Blackwater River	69.00	94.00	10/2/2009

* Indicates that the individual was identified as a female by the U. S. Fish and Wildlife biologist present during tagging efforts

As previously mentioned, 86 sturgeon were detected on Eglin’s receivers during the 2009 Legacy Study. Table 17 shows the breakdown of where the sturgeon came from and which organization tagged them.

Table 17. Number of Sturgeon Detected from Different River Systems and Associated Studies

# of Sturgeon Detected	Year Tagged	Location Tagged	Tagging Organization
39	2009	Pensacola Bay System Rivers	Eglin 2009 Legacy Study
14	2008	Choctawhatchee River	Eglin 2008 Pilot Study
30	2009	Choctawhatchee River	Delaware State University ¹
3	2005	Escambia River	National Oceanic & Atmospheric Administration ²

1. Ongoing study by K. Fleming, D. Fox, and F. Parauka

2. Duncan et al., submitted for publication

It is important to note that the studies conducted by Delaware State University (DSU) and the National Oceanic & Atmospheric Administration (NOAA) are separate efforts and are not connected to Eglin’s study. However, since they used the same acoustic equipment, Eglin’s receivers were able to detect individuals from these studies and these detections are therefore included in this analysis only as observations of the amount of sturgeon activity within Eglin’s Gulf ranges. Tag IDs from these studies were confirmed with both organizations. This report does not include any results from these studies.

Table 18 below shows the tag IDs recorded on Eglin’s receivers from these other two studies.

Table 18. Tag IDs for Sturgeon Detected from Other Studies

DELAWARE STATE UNIVERSITY		
62392*	62408*	62420**
62393*	62409*	62421**
62394*	62410*	62422**
62396*	62411*	62423**
62397*	62412**	62424**
62400*	62413**	62425**
62401*	62415**	62426**
62404*	62416**	62428**
62405*	62418**	62429**
62407*	62419**	62431**
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION		
843	859	860

*Indicates juvenile sturgeon with tags that emit a transmission every 30 – 55 seconds

**Indicates adult sturgeon with tags that emit a transmission every 15 – 45 seconds

DSU’s study tagged juvenile sturgeon (19 individuals), as well as adult sturgeon (21 individuals) (Fleming et al., 2010). Since they were dealing with smaller sturgeon, the tags used by DSU had different ping intervals than Eglin’s. As mentioned in the Methodology section, the tags utilized by Eglin were set to ping once every 30 – 90 seconds with a nominal time of 60 seconds. DSU utilized two different sized tags to accommodate for smaller juveniles and larger adult sturgeon. The smaller tags inserted into the juvenile sturgeon had smaller batteries. To optimize battery usage, the 19 juvenile sturgeon had tags that pinged every 30 – 55 seconds and the 21 adult sturgeon had tags that pinged every 15 – 45 seconds (Fleming, 2010). There was no information about the delay times for the tags used on the 3 individuals detected from the 2005 NOAA Study.

Between late September 2009 and May 2010, all receivers deployed for the 2009 Legacy Study collected a total of 161,569 detections. Table 19 shows the number of detections received from each study and river origin.

Table 19. Number of Detections Received and Associated Study/River Origin of Tagged Sturgeon

Sturgeon Study	River System	# of Detections	% of Total
Eglin 2009 Legacy Study	Pensacola Bay System Rivers	64,683	40%
Eglin 2008 Pilot Study	Choctawhatchee River	19,832	12%
DSU Study ¹	Choctawhatchee River	76,787	48%
NOAA 2005 Study ²	Escambia River	267	<1%

1. Ongoing study by Fleming et al.

2. Duncan et al., submitted for publication

As the table shows, the majority of detections received during the 2009 – 2010 winter season came from sturgeon tagged in the Choctawhatchee River system. Choctawhatchee River sturgeon accounted for over 51% of the number of sturgeon detected and nearly 60% of the number of detections received (Tables 17 and 19). While the differing ping intervals used in the sturgeon tagged by DSU originating from the Choctawhatchee River may account for the higher number of detections, the results still show that sturgeon from this river system play a key role in determining the amount of sturgeon activity in Eglin’s Gulf ranges.

Figures 20 and 21 show the number of detections and the number of sturgeon detected during the 2009 – 2010 winter season, respectively for the different river systems.

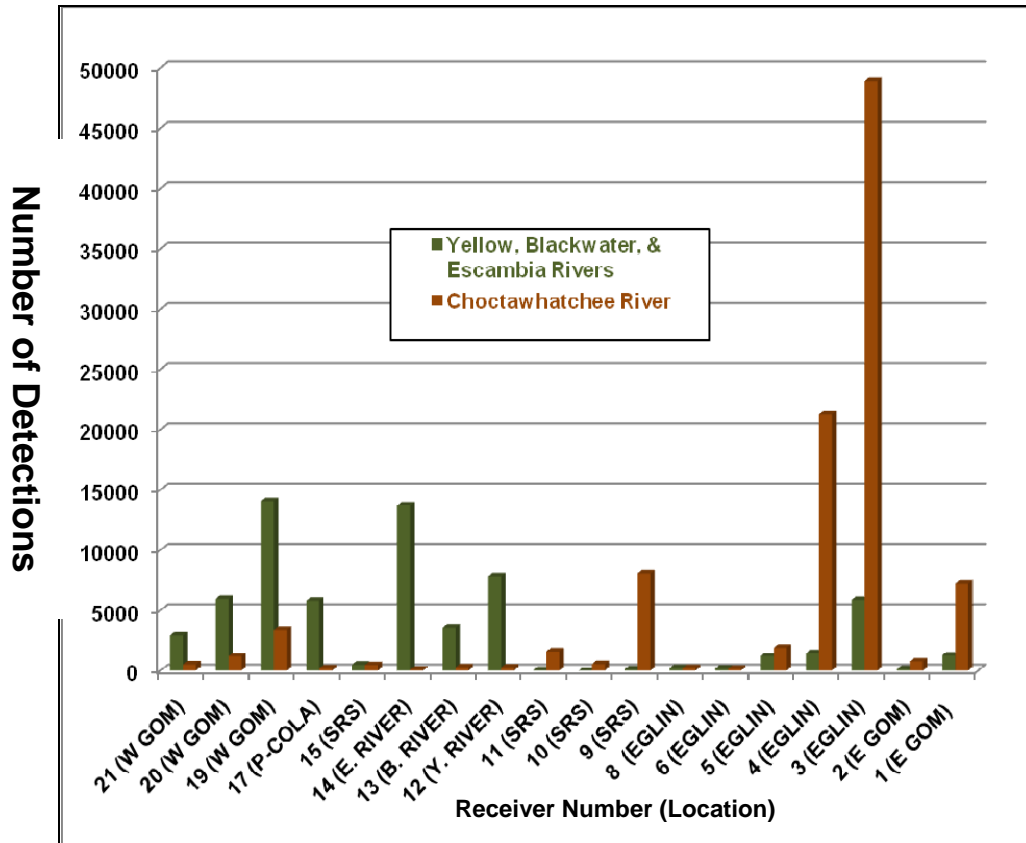


Figure 20. Number of Detections

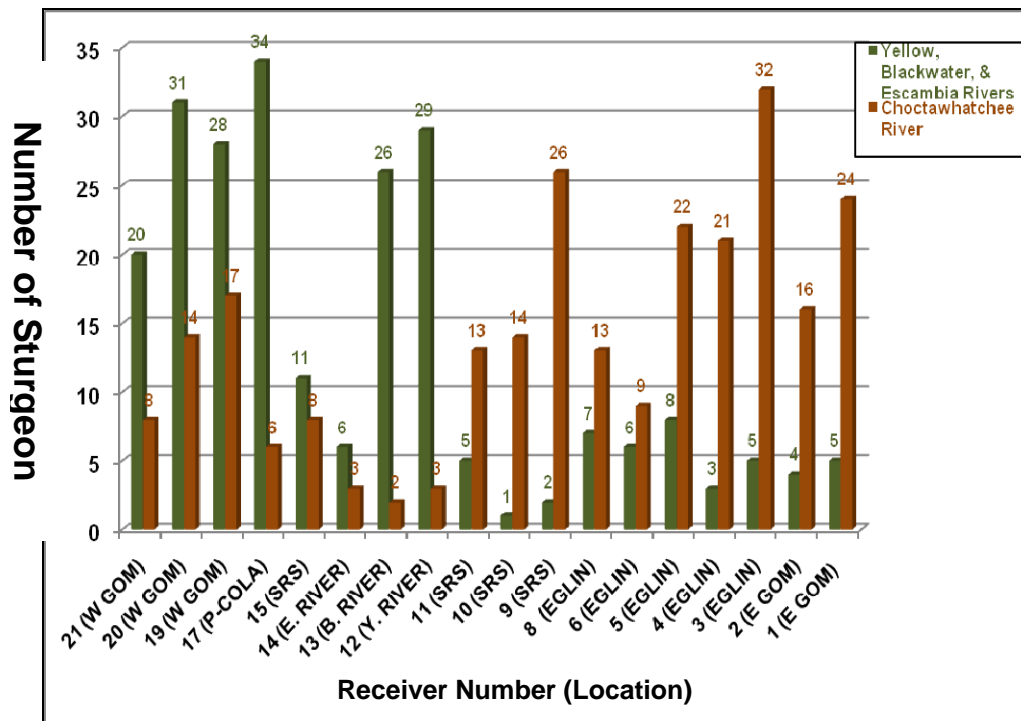


Figure 21. Number of Sturgeon Detected

The amount of sturgeon activity within Eglin’s Gulf ranges appears to be predominantly from sturgeon tagged in the Choctawhatchee River. This is shown by both the number of detections and the number of sturgeon detected on each of the EGLIN receivers. Specifically, receiver 3 has the highest number of detections and the second highest number of sturgeon detected of all receivers located in the Gulf. This suggests that this area in Eglin’s Gulf range is a hot spot for sturgeon activity, however given the differing ping rates for the sturgeon tagged by DSU, separating the data associated with these individuals from the rest of the group is necessary to form more accurate conclusions.

Table 20 shows the numbers of detections and numbers of sturgeon detected per receiver for each represented study. The ratio of detections/sturgeon have also been calculated and included in the table for comparison.

Table 20. Detections/Sturgeon Ratios for Each Study and River System

Receiver ID		Eglin 2009 Legacy Study: Yellow, Blackwater, & Escambia Rivers			Eglin 2008 Pilot Study: Choctawhatchee River			Delaware State University: Choctawhatchee River		
		Detections	Sturgeon	Ratio	Detections	Sturgeon	Ratio	Detections	Sturgeon	Ratio
W GOM	21	2940	22	134	47	1	47	462	5	92
	20	5924	31	191	422	4	106	774	10	77
	19	14068	28	502	167	5	33	3192	12	266
P-COLA	17	5780	34	170	3	1	3	180	5	36
RIVER	14	13718	7	1960	0	0	0	78	2	39
	13	3528	26	136	0	0	0	273	2	137
	12	7827	29	270	2	1	2	254	2	127
SRS	15	484	12	40	22	1	22	434	6	72
	11	49	5	10	55	3	18	1539	10	154
	10	5	1	5	129	3	43	406	11	37
	9	100	2	50	801	6	134	7258	20	363
EGLIN	8	213	8	27	76	6	13	137	6	23
	6	162	5	32	77	5	15	79	5	16
	5	1207	8	151	479	9	53	1405	13	108
	4	1448	3	483	2749	7	393	18538	14	1324
E GOM	3	5843	5	1169	11946	11	1086	36951	21	1760
	2	125	4	31	277	6	46	480	10	48
	1	1262	5	252	2580	9	287	4614	15	308

Showing this graphically (Figure 22) indicates which areas are dominated by sturgeon from different river systems.

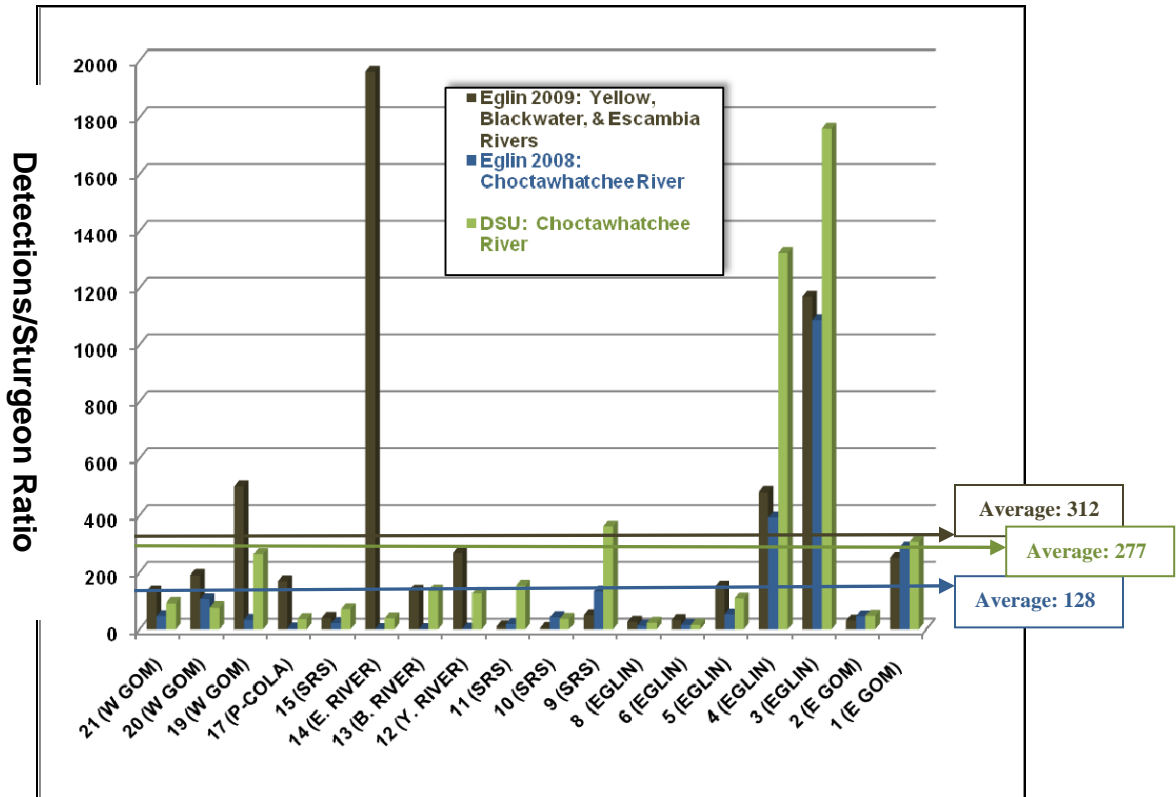


Figure 21. Comparison of Detection/Sturgeon Ratios for Each River System

Comparing the averages of the ratios for each of the groups indicates that even with a higher ping rate, the sturgeon tagged by DSU still have an overall lower average detection per sturgeon ratio. DSU sturgeon likely utilize most of the areas in this study as transit areas, such as SRS, W GOM, and to some extent, EGLIN receiver locations. Looking specifically at EGLIN receivers, it appears that DSU sturgeon account for the majority of sturgeon activity in this area of the Gulf. While the sturgeon activity on the W GOM receivers is predominantly from sturgeon tagged by Eglin in the Pensacola River System, the receivers 3 and 4 area seems to be an area of interest for all tagged sturgeon. Higher numbers of detections received at receivers 3 and 4 may result from more frequent ping rates from a large number of DSU sturgeon; however the E GOM receivers show that the ratios are more closely matched among the 3 groups despite differing ping rates. The ratios for DSU sturgeon at receivers 3 and 4 are much higher than any other location in the Gulf. Given the lower ratios at all other locations, it appears that DSU sturgeon utilize this area in Eglin’s Gulf ranges more than other areas in the Gulf that were monitored for this study.

Sturgeon tagged by Eglin in the Choctawhatchee River for the 2008 Pilot Study and in the Pensacola Bay System Rivers for the 2009 Legacy Study also show an affinity for receivers 3 and 4 in Eglin’s Gulf ranges. Although fewer individuals from these studies were detected, their above average ratios suggest that this area was an attractive location to congregate in during the winter.

Comparison of the area in Eglin’s Gulf ranges to the area near Pensacola Pass and Perdido Key where W GOM receivers were deployed demonstrates how sturgeon utilize these areas of the Gulf differently. The majority of the sturgeon detected on the W GOM receivers were originally tagged in the Pensacola Bay System Rivers and likely traveled through Pensacola Bay and entered the Gulf through the Pensacola Pass. Several sturgeon from the Choctawhatchee River system were also detected on these western-most receivers. The detections/sturgeon ratios indicate that none of these individuals remained in the area for long periods of time. These sturgeon were heading to a location farther west for the winter, but the western extent of their journey is unknown.

4. Movement and Distribution Patterns in the Gulf of Mexico

This section will look only at the Gulf of Mexico area, with focus on receivers within Eglin’s Gulf ranges. Other areas of the Gulf will be examined for comparison to note any usage changes among the different areas of the Gulf. As the previous section discussed, the arrays within Eglin’s Gulf ranges, specifically numbers 3 and 4, experienced a high volume of sturgeon activity over the winter from sturgeon tagged in multiple river systems. The maps in Figures 10 – 17 show the temporal changes in detections, but they did not differentiate river origins of the detected sturgeon. Figures 22 – 27 illustrate how numbers of detections and numbers of sturgeon detected change temporally and spatially, and separate these data according to the river origins of the sturgeon.

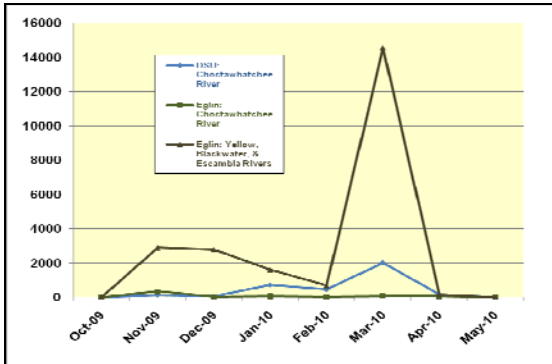


Figure 22. Detections on W GOM Receivers over Time

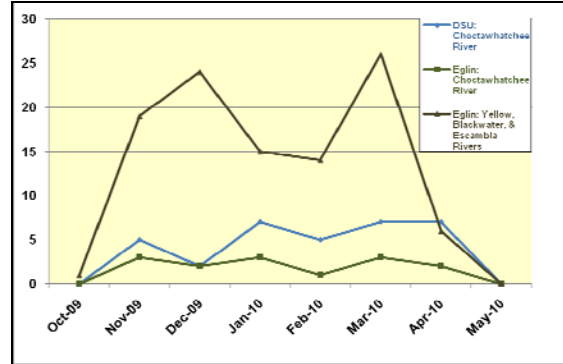


Figure 23. Sturgeon Detected on W GOM Receivers over Time

Gulf sturgeon activity on the W GOM receivers was predominantly from sturgeon tagged in either the Pensacola Bay System Rivers, all of which entered the Gulf via the Pensacola Pass. The number of Pensacola Bay System River sturgeon detected on the W GOM receivers was relatively high in November and continued to increase in December even though the number of detections were close to the same level in both months. The number of sturgeon detected on W GOM receivers that entered the Gulf through the Pensacola Pass decreased in January; however more sturgeon migrating from the Choctawhatchee River system were detected as those few individuals were continuing their western journey for the winter. All groups of sturgeon showed a decline in the level of activity at these receivers in February. The last detections documented from receiver 21 were received on 2/13/2010. No more data were collected from that receiver after that point because it was missing during the following download attempt, which may have

contributed to the decrease in detections and sturgeon detected. The month of March marked the beginning of the sturgeon’s migration out of the Gulf for the spring. This is evident through the drastic increase in both the amount of detections and number of sturgeon detected on receivers 19 and 20 near the Pensacola Pass. March proved to be the month of highest sturgeon activity in this part of the Gulf. By April, this level of activity greatly diminished and by May virtually all activity had ceased, marking the end of sturgeon overwintering in the Gulf.

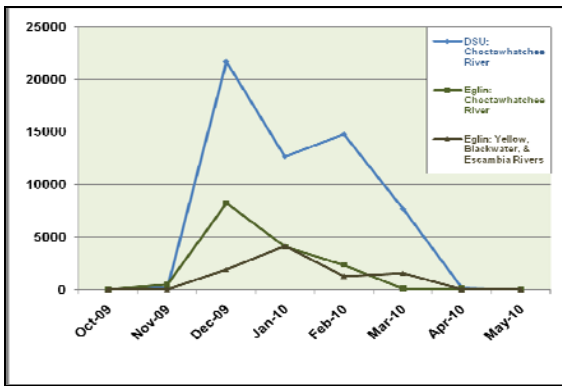


Figure 24. Detections on EGLIN Receivers over Time

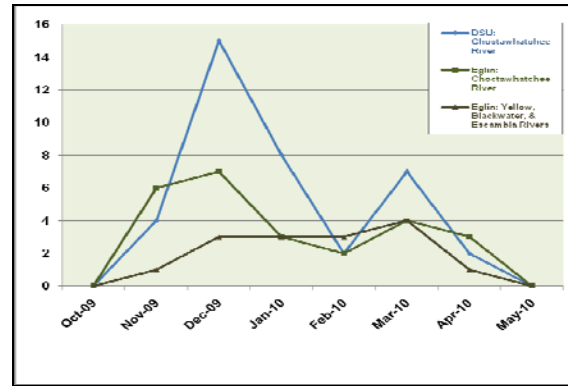


Figure 25. Sturgeon Detected on EGLIN Receivers over Time

Gulf sturgeon’s utilization of their habitat within Eglin’s Gulf ranges differs from that of the area near the Pensacola Pass and Perdido Key where W GOM receivers were located. Both areas of the Gulf experience moderate increases in both detections and number of sturgeon detected during the month of November. But by December, the EGLIN receivers document high levels of detections and high numbers of sturgeon detected. While more individual sturgeon were detected on W GOM receivers than on EGLIN receivers in December, the amount of detections (or number of pings) received on EGLIN receivers was more than ten times the amount of detections received on W GOM receivers. The majority of the sturgeon detected on W GOM receivers were from sturgeon tagged in the Yellow, Blackwater, or Escambia Rivers and the majority of the sturgeon detected on EGLIN receivers were from the Choctawhatchee River, specifically from individuals tagged by DSU. Even with the differing ping rates associated with sturgeon tagged by DSU, calculating and comparing detections/sturgeon ratios for each group of sturgeon indicates that the sturgeon detected on EGLIN receivers remained in the area for a longer period of time than in any other area in the Gulf (Tables 21, 22, and 23).

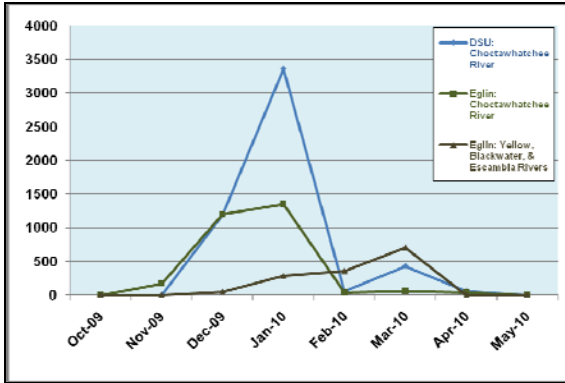


Figure 26. Detections on E GOM Receivers over Time

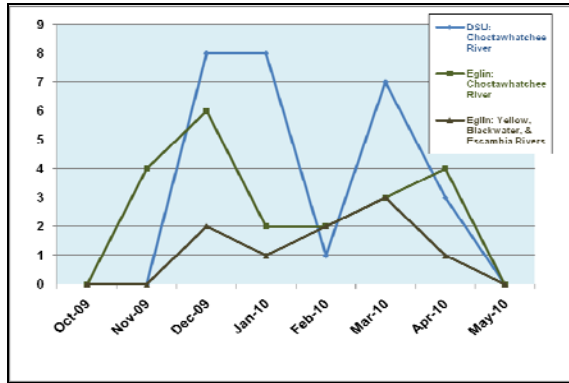


Figure 27. Sturgeon Detected on E GOM Receivers over Time

The proximity of the locations of E GOM receivers to Choctawhatchee Bay can likely account for the higher numbers of detections received and sturgeon detected from individuals tagged in the Choctawhatchee River than the other river systems represented in this study. Similar to the areas within Eglin's Gulf ranges, sturgeon activity in the Gulf east of the Destin Pass begins at low levels in November, increases in December, and peaks in January. This area also experiences a drop in detections and number of sturgeon detected during the month of February. Since this is a trend seen in all areas of the Gulf monitored in this study, it appears that sturgeon's endpoint of their winter migration occurs in February; however the location of this endpoint is not fully known. For some individuals, the endpoint appeared to be within Eglin's Gulf range, as evidence through the increase in detections received that month (Figure 24) despite the decrease in the number of sturgeon detected (Figure 25). In all cases, the number of sturgeon detected during March increased significantly. For E GOM receiver, the majority of sturgeon detected in March were those individuals tagged in the Choctawhatchee River, indicating that they were beginning their migration back into the Choctawhatchee Bay before re-entering the Choctawhatchee River for the spring and summer. The number of detections on E GOM receivers only peaked slightly in March, which suggests that the sturgeon were not congregating in this area for very long. All Gulf receivers were collected in April; however, detections from one individual up to the day the receivers were collected suggests that some adult sturgeon may linger in the Gulf longer than what was previously thought.

The following tables show the detections/sturgeon for each group represented in this study. Comparing the ratio over time for each area of the Gulf monitored in this study helps identify how sturgeon from different river systems utilize each area of the Gulf. Higher detections/sturgeon value indicates that the sturgeon detected on the respective receivers spent more time in that area as opposed to other areas where the detections/sturgeon value was lower. The sturgeon tagged by DSU were separated from those tagged by Eglin to account for the different ping intervals of the tags that were inserted into those individuals.

Table 21. Detections/Sturgeon Ratios for Sturgeon Tagged by Eglin in the Yellow, Blackwater, and Escambia River (Average: 312)

	W GOM (19, 20, & 21)	EGLIN (3, 4, 5, 6, & 8)	E GOM (1 & 2)
October 2009	3	0	0
November 2009	152	21	0
December 2009	116	632	24
January 2010	108	1376	281
February 2010	49	425	177
March 2010	560	388	234
April 2010	28	2	2
May 2010	0	0	0

Table 22. Detections/Sturgeon Ratios for Sturgeon Tagged by Eglin in the Choctawhatchee River (Average: 128)

	W GOM (19, 20 & 21)	EGLIN (3, 4, 5, 6, & 8)	E GOM (1 & 2)
October 2009	0	0	0
November 2009	117	84	43
December 2009	16	1172	201
January 2010	20	1359	674
February 2010	44	1173	18
March 2010	26	24	19
April 2010	26	34	11
May 2010	0	0	0

Table 23. Detections/Sturgeon Ratios for Sturgeon Tagged by DSU in the Choctawhatchee River (Average: 277)

	W GOM (19, 20 & 21)	EGLIN (3, 4, 5, 6, & 8)	E GOM (1 & 2)
October 2009	0	0	0
November 2009	28	48	0
December 2009	38	1446	149
January 2010	104	1581	420
February 2010	91	7383	61
March 2010	289	1097	61
April 2010	22	72	19
May 2010	0	0	0

Months and areas where ratios were higher than the groups' averages are highlighted in red. All three groups have elevated detections/sturgeon ratios on EGLIN receivers between the months of December and March. As noted in the discussion above, the W GOM receivers experienced a high level of sturgeon activity during the month of March as these individuals had begun their spring migration back to the bays and rivers. Furthermore, the E GOM receivers experienced some spill-over activity from sturgeon tagged in the Choctawhatchee River during December and January as well. All other areas and timeframes in the Gulf, therefore, are not heavily congested with sturgeon

activity, as they likely serve as migration routes within their Gulf overwintering habitat area.

5. River Fidelity

It is typically assumed that anadromous fish will return to the same river each spring/summer to spawn. Examination of the locations of original tagging and that of last detection revealed that a number of sturgeon moved from one river system to another (highlighted in yellow in Table 24). Some sturgeon tagged by DSU in the Choctawhatchee River were also detected in the spring on some of the RIVER receivers (Pensacola Bay System Rivers); exact tagging information on these individuals is unknown.

Table 24. Beginning and Ending Locations of Sturgeon Tagged for the 2009 Legacy Study

Vemco® Tag ID	Location Tagged	Date Tagged	Location of Last Detection	Date of Last Detection
61006	Blackwater River	10/2/2009	Escambia River (14)	4/16/2010
61007	Blackwater River	9/30/2009	Pensacola Bay (17)	3/12/2010
61008*	Escambia River	9/30/2009	Escambia River (14)	5/5/2010
61009	Blackwater River	9/30/2009	Yellow River (12)	3/12/2010
61010*	Blackwater River	10/2/2009	Yellow River (12)	5/15/2010
61011*	Blackwater River	9/30/2009	NO DETECTIONS	
61012	Blackwater River	10/2/2009	Yellow River (12)	5/9/2010
61013	Blackwater River	10/2/2009	Yellow River (12)	4/27/2010
61014	Blackwater River	10/2/2009	Gulf of Mexico (1)	3/26/2010
61015*	Escambia River	9/30/2009	Blackwater River (13)	4/21/2010
61016*	Yellow River	9/18/2009	Santa Rosa Sound (15)	3/19/2010
61017	Yellow River	9/11/2009	Yellow River (12)	3/21/2010
61018*	Blackwater River	9/21/2009	Yellow River (12)	5/3/2010
61019	Yellow River	9/18/2009	Yellow River (12)	5/14/2010
61020*	Yellow River	9/18/2009	Yellow River (12)	4/23/2010
61021	Yellow River	9/18/2009	Yellow River (12)	4/26/2010
61022	Yellow River	9/18/2009	Yellow River (12)	3/12/2010
61023	Yellow River	9/18/2009	Yellow River (12)	4/1/2010
61024	Yellow River	9/11/2009	Yellow River (12)	5/9/2010
61025	Yellow River	9/11/2009	Yellow River (12)	3/28/2010
61026	Yellow River	9/11/2009	Yellow River (12)	4/2/2010
61027	Yellow River	9/11/2009	Yellow River (12)	3/28/2010
61028*	Blackwater River	9/21/2009	Blackwater River (13)	5/19/2010
61029*	Blackwater River	9/21/2009	Yellow River (12)	4/22/2010
61030	Blackwater River	9/21/2009	Blackwater River (13)	5/7/2010
61031	Blackwater River	9/21/2009	Yellow River (12)	5/1/2010
61032	Blackwater River	10/2/2009	Blackwater River (13)	4/22/2010
61033	Escambia River	9/30/2009	Escambia River (14)	4/5/2010
61034*	Blackwater River	9/22/2009	Blackwater River (13)	5/5/2010
61035*	Blackwater River	9/22/2009	Yellow River (12)	4/13/2010
61036	Yellow River	9/29/2009	Yellow River (12)	3/30/2010
61037	Blackwater River	9/21/2009	Blackwater River (13)	5/18/2010
61038*	Blackwater River	9/21/2009	Yellow River (12)	4/18/2010
61039*	Blackwater River	9/21/2009	Blackwater River (13)	5/16/2010
61040*	Blackwater River	9/21/2009	Yellow River (12)	4/13/2010
61041	Blackwater River	10/2/2009	Yellow River (12)	5/15/2010
61042*	Blackwater River	10/2/2009	Escambia River (14)	4/5/2010
61043	Blackwater River	10/2/2009	Blackwater River (13)	5/19/2010

Vemco® Tag ID	Location Tagged	Date Tagged	Location of Last Detection	Date of Last Detection
61044*	Blackwater River	10/2/2009	Yellow River (12)	5/9/2010
61045*	Blackwater River	10/2/2009	Blackwater River (13)	5/8/2010
62393**	Choctawhatchee River	unknown	Escambia River (14)	5/19/2010
62396**	Choctawhatchee River	unknown	Blackwater River (13)	5/14/2010
62405**	Choctawhatchee River	unknown	Yellow River (12)	4/28/2010

* Indicates that the individual was identified as a female by the U. S. Fish and Wildlife biologist present during tagging efforts.

**Individuals were part of the DSU Study. Specific tagging information about them is not known.

Since information on sturgeon tagged by DSU is limited, the remainder of this discussion will focus on sturgeon tagged by Eglin in 2009 only; however it is interesting to note that these Choctawhatchee-tagged sturgeon were detected in the Escambia and Yellow Rivers during the spring, which suggests that they chose to spawn there instead of the Choctawhatchee River.

Of the 39 sturgeon detected during the 2009 Legacy Study, only 22 (56%) returned to the same river where they were originally tagged. Of the remaining 17, three had not been detected on any of the RIVER receivers before the final download occurred at the end of the study. Based on the date of their last detections being in March, it is likely that these individuals had not completed their spring migration by 5/19/2010 when the final download occurred (Table 3), thus their exact river endpoint is not known. However, 17 sturgeon (44% - includes 2 sturgeon that went to another river before returning to their river origin) were documented to occur in rivers where they were not originally tagged. Fourteen of these sturgeon were originally tagged in the Blackwater River, but 12 were later detected in the Yellow River and 2 were later detected in the Escambia River in the spring. One sturgeon tagged in the Escambia River was later detected in the Blackwater River in the spring. Furthermore, two individuals (61039 and 61045) originally tagged in the Blackwater River showed detections in the Yellow River in April before heading back to the Blackwater River in May. This apparent lack of fidelity to one river system for this group of sturgeon justifies studying these river systems as one group since sturgeon seem to travel back and forth between these rivers during the spring. This finding is supported by evidence collected by USFWS personnel suggesting that sturgeon from the Yellow and Blackwater Rivers may be considered one population. This fact also raises the question of what other nearby rivers, (i.e., the Shoal River) do these sturgeon occupy that have not been included in this or any other study.

6. Comparison of Weather Data and Detection Rates in the Marine Environment

6.1 *Methodology*

The marine environment provides a more turbulent setting for conducting acoustic telemetry studies when compared to calmer estuarine or riverine environments. The sea state of the Gulf changes on a daily and, at times, hourly basis usually dependent on weather and wind speed. High levels of boat traffic and regular changes in tide also contribute to a wide range of changes in the study area which may interfere with the receiver's ability to detect transmissions. Differing ping rates, moving fish, and

unpredictable weather in a harsh marine environment were identified as potential issues that may impact a receiver’s detection rate, (i.e., the receiver’s success in detecting or receiving transmissions from nearby tags). A separate Vemco® V16 acoustic transmitter was used as a dedicated sentinel tag (test pinger) and was placed in the Gulf approximately 500 meters from one receiver (3) and 350 meters from another (4) for a period of 3 months to determine what percentage of actual detections were received over time. The test pinger (pinging at a rate of once every 15 minutes) was placed at the bottom of the Gulf to simulate a stationary fish emitting a continuous and regular transmission to the surface buoy/receivers (Figure 28). Once deployed, both receivers began receiving detections from the test pinger.

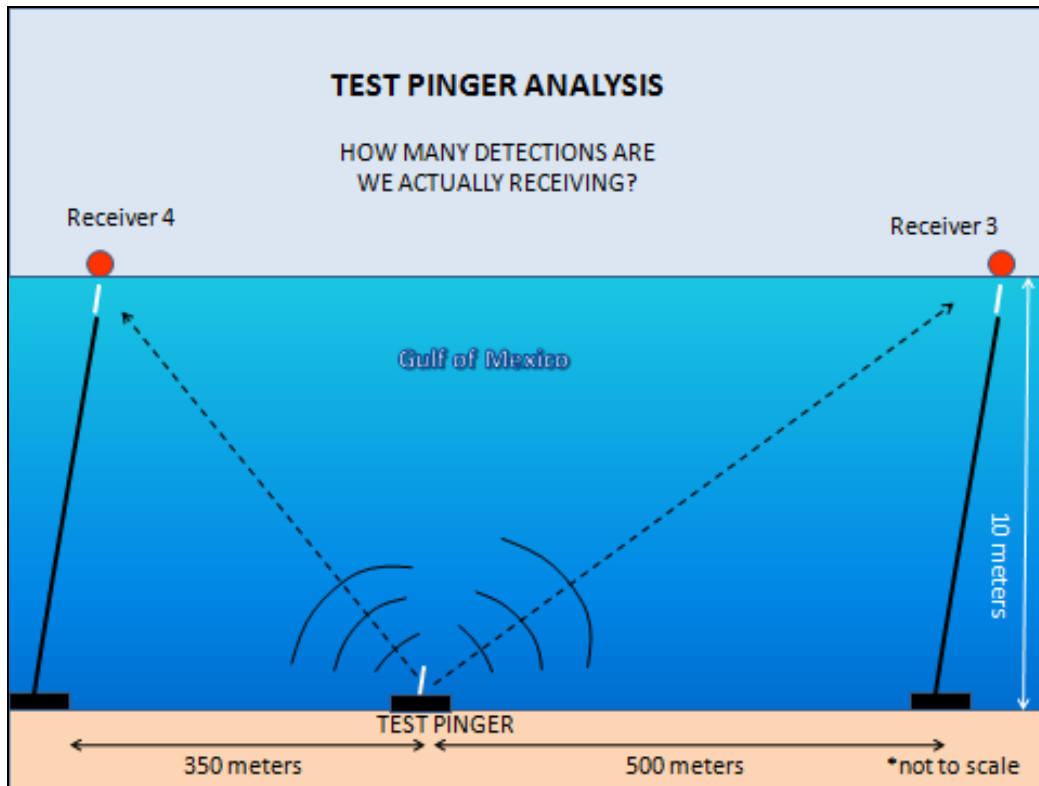


Figure 28. Diagram of Placement of Test Pinger Between Inshore (3) and Offshore (4) Receivers

6.2 Results

Each time the receivers were downloaded (Table 3), the test pinger ID was separated out from the rest of the data. Test pinger data from both receivers were compiled and analyzed. Missing detections were noted when a time span greater than 15 minutes passed in between detections. The corresponding wind speed was collected and compared to the times with missing detections. Based on the comparison, a negative correlation was found such that low detection rates typically occurred during time periods of high winds and high detection rates usually occurred during time periods of low winds (Figure 29). As indicated by the green arrows, there was only one day when the maximum possible detections were received; this day, the wind speed was 0 mph. Alternately, the red arrows point out days when no detections were received and wind speeds were high.

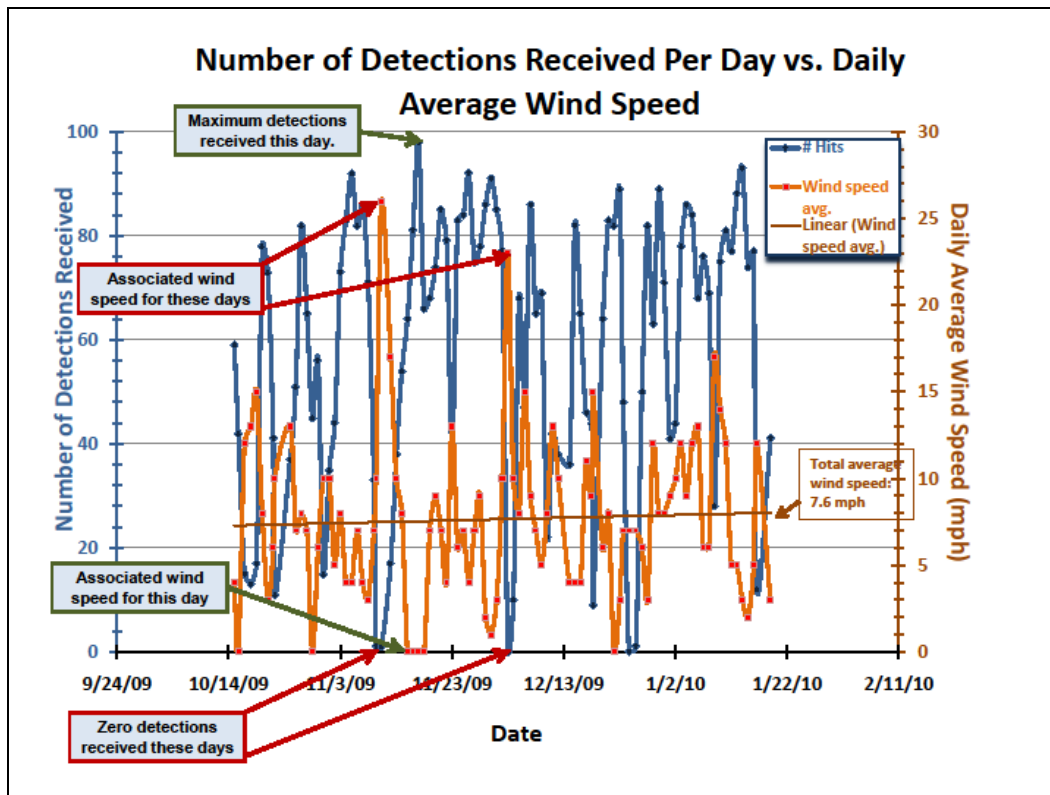


Figure 29. Negative Correlation between Wind Speed and Detections Received

To focus in on this correlation, the specific detection rate associated with a given wind speed was calculated for the data set. To calculate detection rates for a given day, the total detections received per day on both receivers were tallied and averaged. The detection rate was determined by dividing the average number of detections received by the maximum possible detections. The maximum possible number of detections received would be 96 per day (4 pings/hour x 24 hours). Daily average wind speed was also collected. Table 25 shows this information for a few selected days within the entire data set.

Table 25. Detection Rates and Average Wind Speed for Selected Days

DATE	Average Detections Received	Calculated Detection Rate	Average Daily Wind Speed (mph)
12/2/2009	0	0%	23
11/10/2009	1	1%	26
1/8/2010	22	23%	17
12/15/2009	24	25%	15
1/1/2010	30	31%	10
1/5/2010	39	41%	13
12/25/2009	54	56%	7
1/16/2010	55	57%	12
1/7/2010	62	65%	6
12/21/2009	68	71%	0
12/30/2009	68	71%	8
1/3/2010	68	71%	9

DATE	Average Detections Received	Calculated Detection Rate	Average Daily Wind Speed (mph)
1/15/2010	71	74%	5
12/15/2009	74	77%	4
1/9/2010	75	78%	14
1/18/2010	76	79%	3
1/14/2010	80	83%	2
11/29/2009	91	95%	1

Figure 30 shows the relationship between detection rates and daily average wind speed where detection rates (in percentages) were plotted over wind speed (in miles per hour); a trend line was fitted to this curve to estimate average detection rates for a given wind speed.

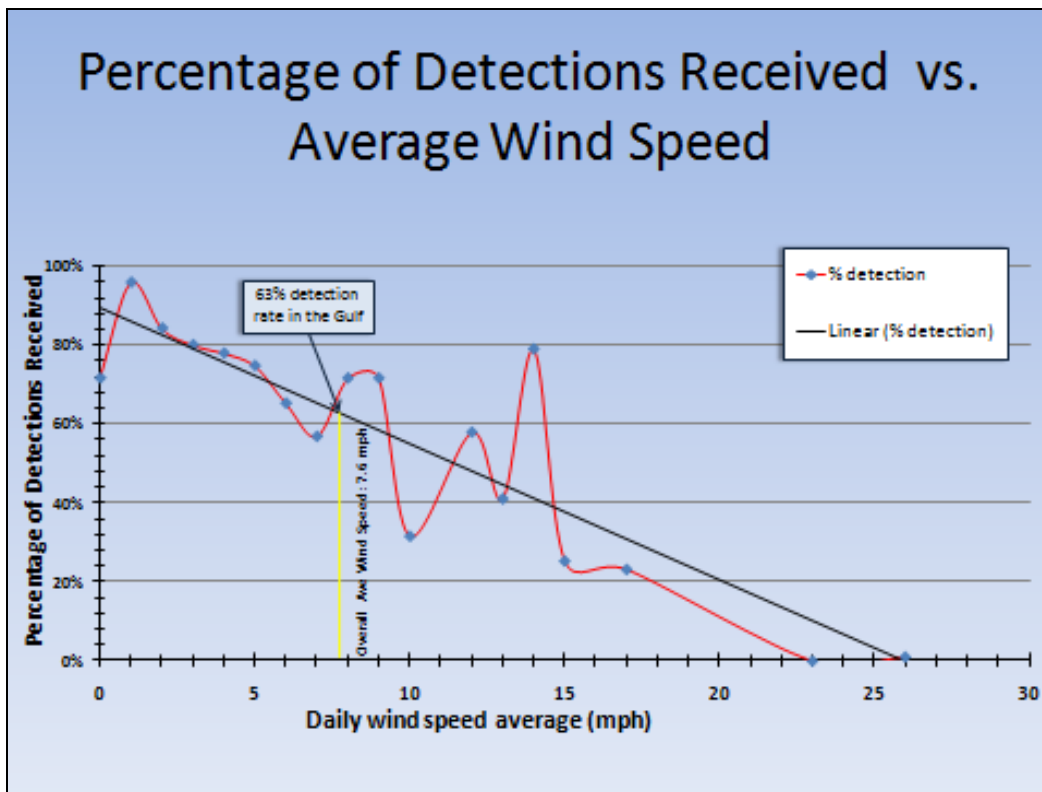


Figure 30. Percentage of Detections Received vs. Average Wind Speed

Figure 30 shows that weather conditions causing wind speeds greater than 15 mph (which can produce waves in the Gulf greater than 3 feet) can lower a receiver's detection success to 20% or less. A fairly high (75% or more) detection rate was found for winds that were less than 5 mph. The percentage of detections received during wind speeds between 10-15 mph produced variable detection rates between approximately 40 and 60%. The reason for this level of variation is not known; however changes in wind direction (i.e., northerly vs. southerly or leeward vs. windward) affects the sea state differently, which can create different levels of interference in the water column that prevents the receivers from detecting transmissions. The average wind speed over the

course of the test pinger investigation was approximately 7.6 mph. Therefore, according to the results of this investigation, an estimated 63% of all transmissions emitted from the tags would be detected by receivers deployed in this part of the Gulf.

The receivers within the array were arranged such that an acoustic fence would be created that would presumably detect all tagged sturgeon traveling east and west through the Gulf. The distance between receivers was estimated based on the receiver’s detection range such that there would not be any gaps between the receivers where sturgeon could potentially swim through the fence undetected. Part of this test pinger investigation was to determine the receiver’s detection range in the Gulf environment. Comparing the data downloaded from receiver 4 (350 meter distance) and receiver 3 (500 meter distance), revealed that receiver 3 contained far fewer detections than receiver 4. Hourly wind data was collected and compared with the hourly detections received on each receiver to determine what the weather conditions were during the time periods of missing detections. The results indicate that a the receiver’s ability to pick up detections is likely less than 500 meters, specifically when wind speeds exceed 15 mph (Figure 30). A range of 350 meters may be more accurate in a Gulf setting, as receiver 4 detected transmissions that were missed on receiver 3 under the same weather conditions.

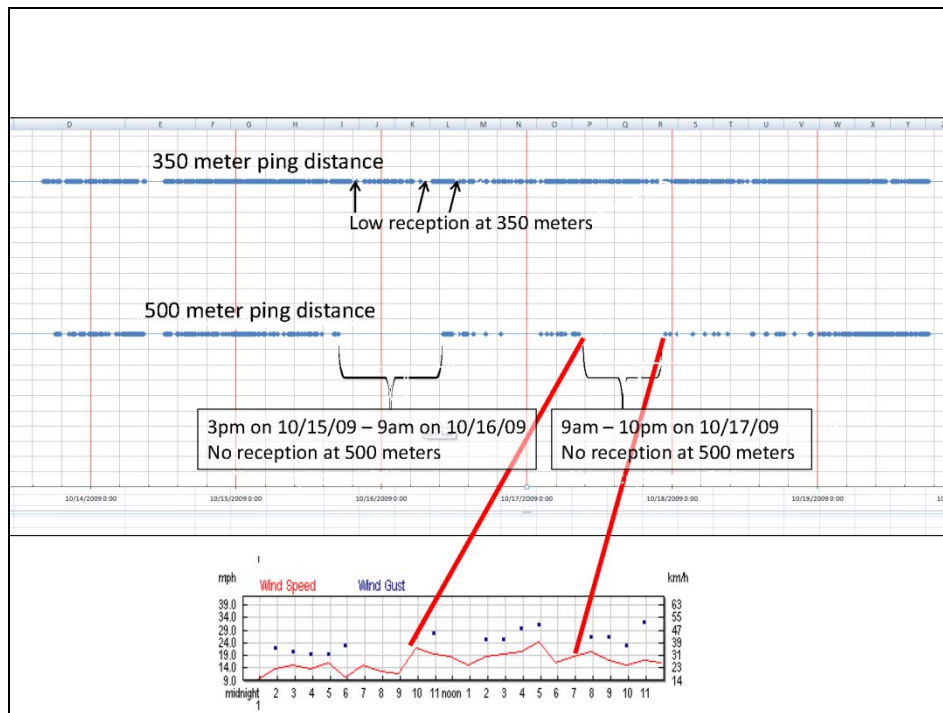


Figure 31. Detections Received During Test Pinger Study on Receivers 3 (500 m ping distance) and 4 (350 m ping distance)

This test pinger investigation illustrates how a receiver performs in a marine environment. To create an array of receivers in the Gulf that would not miss tagged sturgeon swimming in between receivers, it appears a distance up to 700 meters between receivers would be adequate ensure maximum detections of transmissions, even during weather conditions that yield high wind speeds.

VII. Conclusions

With the help of acoustic telemetry, Eglin has been successful in determining Gulf sturgeon's presence and movements within critical habitat areas of Eglin's Gulf ranges. Two years of tagging and tracking sturgeon during the winter has resulted in Eglin's ability to narrow down the areas in the Gulf where sturgeon typically occur to be within 1,000 meters of the shoreline (2008 Pilot Study). Furthermore, strategic placement of receivers in the Gulf has allowed Eglin to determine potential hot spots in the area and to identify different behavior patterns for specific locations in the Gulf based on the river origins of the tagged sturgeon (2009 Legacy Study). The main area of interest within Eglin's Gulf ranges appears to be within 1,000 meters offshore of the Eglin NCO Beach Club, just west of the Destin Pass. Gulf sturgeon activity in this area of the Gulf starts in November with peaks in December and January and lasts until April. Receivers 3 and 4 were deployed in this area and experienced the highest levels of sturgeon activity, both in numbers of detections and number of sturgeon detected during this time period. The majority of the sturgeon documented in this area originate from the Choctawhatchee River, but some individuals were identified from the Yellow, Blackwater, and Escambia River systems as well. All sturgeon detected on these receivers seemed to linger in this area for a longer period of time, compared to other areas in the Gulf. This was based on the detections/sturgeon ratios calculated for all receivers deployed in the GOM and separated based on the fact that some sturgeon were tagged with acoustic transmitters with different ping rates. It is interesting to note that the sturgeon showed increased activity in this area and remained in the Gulf longer in the 2009 Legacy Study than what was found in the 2008 Pilot Study. Subsequent years of study will be able to determine whether this type of behavior is typical, or if there were other outside factors causing this area to be more attractive to the sturgeon than normal.

The W GOM receivers, showed a different trend of sturgeon movement for the area around Pensacola Pass and Perdido Key. Similar to receivers 3 and 4, receivers 19, 20, and 21 documented high numbers of sturgeon detected, but much lower numbers of detections. This is further demonstrated by the lower detections/sturgeon ratios calculated for these receivers. Based on this, it appears that this area of the Gulf is mostly used as a migration corridor in the winter as sturgeon travel west to different areas of the Gulf. The majority of the sturgeon detected on these receivers were individuals tagged in the Yellow, Blackwater, and Escambia Rivers, and a few were from the Choctawhatchee River. Both groups of sturgeon demonstrated similar behavior, which is based on lower detections/sturgeon ratios for both groups. The only deviation from this occurred in March for both groups, as this was likely the beginning of the sturgeon's resurgence back into the bays and rivers in the spring.

River fidelity of sturgeon was also examined and the data show that even though the group of sturgeon tagged by Eglin in 2009 were from different river systems, 44% were documented to occur in river systems other than the one they were originally tagged in. Sturgeon movements within neighboring river systems should be further examined. On April 28, 2010, Eglin performed a river float study of the Shoal River, which connects to the Yellow River and where critical habitat for Gulf sturgeon is designated for part of the

river. Two sturgeon (61044 and 61018) were documented in the Shoal River accounting for 6 detections within approximately 30 minutes. Both individuals were females originally tagged in the Blackwater River. Another river float study on May 13, 2010 resulted in another female (61029) being detected in the Shoal River as well. The significance of this is not yet known as more studies in this area are required to form any concrete conclusions.

Examining the receivers' detection rates in the Gulf provided much needed insight into how this acoustic technology performs under adverse weather and highly variable marine environments. Even with the high numbers of detections received in one season, it should be noted that this may not fully represent the extent or true level of sturgeon occurrence in the Gulf of Mexico. The test pinger data obtained in this investigation suggests that on average approximately 37% of detections are being missed. It is impossible to determine when these missed detections are occurring, but the data presented in this report can be taken as a lower-level estimate, in that more sturgeon may inhabit this area of the Gulf for a longer period of time than what was documented. Furthermore, the analysis showed a high level of variability in detection rates during wind speeds between 10 and 15 mph. Further investigation and test pinger detections/weather data needs to be collected to provide a more robust data set that will reduce the level of variation or to determine the source of this variation if it is not weather related. For example wind direction and its overall affect on sea state may account for this level of variability, but will need to be investigated further in future studies. The distance between receivers within the array proved to be appropriate, even with the receiver's lower detection range in the Gulf environment, as evidenced from the missing detections at 500 meters that were received at 350 meters.

VIII. Acknowledgements

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