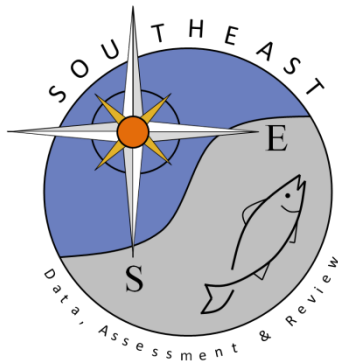


Mark/Recapture Data for the Blacktip Shark, *Carcharhinus limbatus*, in  
the Gulf of Mexico from the NEFSC Cooperative Shark Tagging Program

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**Mark/Recapture Data for the Blacktip Shark, *Carcharhinus limbatus*, in the Gulf of Mexico from the NEFSC Cooperative Shark Tagging Program**

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**Summary**

Mark/recapture data from the National Marine Fisheries Service (NMFS) Cooperative Shark Tagging Program (CSTP) were summarized for the blacktip shark (*Carcharhinus limbatus*) in the Gulf of Mexico from 1964 through 2011. Data on fork length, life stage, movement, time at large, and displacement are provided. No blacktip sharks in this study moved between the Gulf of Mexico and the Atlantic or Caribbean. Similarly, there was no evidence of exchange between the eastern and western Gulf of Mexico. Blacktip sharks were distributed strictly within the 200 m depth contour. Some (n=33) of these sharks migrated from the United States to Mexican waters within a time period of less than one year. Additional tagging of blacktip sharks in Mexico is necessary to further elucidate these exchange patterns.

## Introduction

The blacktip shark, *Carcharhinus limbatus* (Valenciennes in Müller and Henle 1839) is a large coastal shark inhabiting tropical, subtropical, and temperate waters throughout the world (Garrick 1982, Castro 1996). *C. limbatus* is one of the most highly-sought shark species in American fisheries, making it both ecologically and economically important (Castro 1996, Grace and Henwood 1997).

Blacktip sharks have an annual migration cycle that corresponds with a biennial ovulation cycle (Branstetter 1981, Castro 1996). Females either breed or give birth in May to June; post-parturition females are not able to mate again until the following spring. It is believed that the entire population, for both Atlantic and Gulf of Mexico sharks, migrates to more southern waters in the fall. In the following spring, the sharks return to their northern breeding and pupping grounds (Branstetter 1981, Killam 1987, Castro 1993, Castro 1996).

Blacktip sharks in the Gulf of Mexico and the Northwest Atlantic are currently managed by the National Marine Fisheries Service (NMFS) as two separate stocks, but movement patterns and exchange within the Gulf of Mexico are not fully understood (Kohler et al. 1998, Keeney et al. 2003, SEDAR11 2006). Understanding these movement patterns within the Gulf of Mexico is critical for successful management of this species.

## Materials and Methods

The NMFS Cooperative Shark Tagging Program (CSTP) was initiated in 1962. Information on the history and methods of the CSTP are detailed in Kohler et al. 1998. This report summarizes the CSTP mark/recapture information for the blacktip shark in the Gulf of Mexico from 1964 through 2011. The Gulf of Mexico blacktip shark stock is defined as the geographic area from the Florida Keys throughout the Gulf of Mexico (SEDAR11 2006). For the purposes of these analyses, the boundary between the Gulf of Mexico and the Atlantic region was a line beginning on the east coast of Florida at 25°10.4'N latitude, proceeding due east to the U.S. EEZ. Recreational and commercial fishermen conducted the majority of tagging for these sharks, providing information on size, sex, condition, location, and date of capture. The two primary types of tags used were a fin tag (Jumbo Rototag) and a dart tag ("M-tag"). If a tagged shark was recaptured, analogous information was sent to NMFS, allowing for the calculation of time at large, displacement, and speed. Blacktip sharks in the Gulf of Mexico were predominantly caught by rod and reel (n=3272), longline (n=1110), and gill net (n=134). Sharks were also caught in smaller numbers (n<20) with handline, otter trawl, beach seine, set line, hand landing net, and by hand.

Length and weight for CSTP tag returns are reported with varying units of measure. Fork length (FL) was used whenever provided and converted to cm when applicable. Total length (TL) was converted to fork length by rearranging the following formula:  $TL(cm) = (1.1955)FL(cm) + 1.13$  (NMFS SEFSC unpublished data). When neither FL nor TL were provided, weight in kilograms was converted to FL by rearranging the following formula:  $Weight(kg) = (1 \times 10^{-5})FL(cm)^{3.0549}$  (NMFS SEFSC unpublished data).

Sharks were categorized into life stages according to length. The boundary between young of the year and juveniles was defined as the maximum embryo size (cm TL) plus 10%. Using the maximum embryo size of 62.5 cm TL from Garrick (1982), this boundary was calculated to be 56.6 cm FL. Sharks measuring less than 56.6 cm FL were classified as young of the year. Males and females were considered mature when FL was greater than the median length at maturity, 103.4 cm and 117.3 cm, respectively (Carlson et al. 2006). Males and females between 56.6 cm FL and the median length at maturity were considered to be juveniles. Sharks of unknown sex that were between 56.6 cm FL and 103.4 cm FL were categorized as juveniles. Sharks without a size estimate or sharks of unknown sex that were between 103.4 and 117.3 were categorized as "unknown maturity." Sharks of unknown sex that were larger than 117.3 cm FL were categorized as mature. Sharks were classified as embryos when they were taken from pregnant females.

## Results and Discussion

Blacktip sharks were tagged in the Gulf of Mexico every year since 1964. The majority of recaptures occurred during the 1990's, but recaptures continue through the present (Figure 1). Overall, 4415 sharks were tagged, and 130 of these tagged sharks were recaptured, yielding a total of 4545 blacktip shark capture locations in the Gulf of Mexico between 1964 and 2011. Information on these events by sex and life stage is provided in

Table 1. Juveniles were the most commonly caught life stage for both males and females. Females were caught more often than males, resulting in a male to female sex ratio of 1:1.8. The largest blacktip shark was estimated as a 190 cm FL female. The largest measured male and female were 160 and 166 cm FL, respectively.

Female blacktip sharks were tagged in greater numbers than males, resulting in the highest values for: maximum time at liberty (7.8 years), maximum displacement (632 nautical miles), and maximum speed (16.4 nautical miles/day) (Table 2). The blacktip shark that was at liberty the longest and traveled the longest distance was a female tagged off Galveston, Texas in May 1991 and recaptured off Veracruz, Mexico in March of 1999. Young of the year and juvenile sharks had the largest mean displacement; however, there have only been nine mature shark recaptures to date (Figure 2).

Branstetter (1981) reported that blacktip sharks in the north-central Gulf of Mexico were born at 55-60 cm TL (45.1-49.2 cm FL). Castillo-Géniz et al. (1998) reported that the smallest neonate in Mexican waters was 46 cm TL (37.5 cm FL). Excluding the seven sharks specifically listed as embryos, 40 of CSTP tagged sharks were categorized as young of the year (range: 32-37.5 cm FL), and 22 of the 40 (including the smallest) were “measured,” not “estimated” lengths. These 40 young of the year were fairly evenly distributed throughout the east and west Gulf coasts.

Distribution by fork length for tagging events, including all recapture data, is shown in Figures 3 and 4. The smallest shark categorized as a young of the year was 32 cm FL, while the largest mature shark was estimated at 190 cm FL. Blacktip sharks in transitional stages (i.e., young of the year to juvenile, juvenile to mature) were caught in higher numbers than those that were not in transition. Both fork length distributions have peaks around 55 cm FL, corresponding to the boundary between young of the year and juvenile categories (Figures 3-4). As shown in Figure 4, males measuring approximately 100-110 cm FL were relatively common. These values correspond to the size range of maturing males, as shown in Table 3. Similarly, females measuring approximately 110-130 cm FL were relatively common (Figure 4). These values correspond to the size range of maturing females, as shown in Table 3.

Baughman and Springer (1950) suggested that blacktip sharks in the western Gulf of Mexico are smaller than their counterparts in the eastern Gulf. The CSTP data does not support this hypothesis, as blacktip sharks off Texas had a higher mean fork length (97 cm) than those off Florida (80 cm). However, this difference may be confounded by fishing effort and gear selectivity. Texas had a higher proportion of fish caught by longline (87%), compared to Florida (82%). Florida had a higher proportion of sharks caught by gillnet (6%), compared to Texas (1%). Similarly, a higher proportion of sharks off Florida were caught within 3 nautical miles of shore (77%), compared to those off Texas (72%).

Hueter et al. (2006) reported that gillnets have a very high post-release mortality rate (31%). It would therefore be expected that gillnets have a lower percent recapture than other methods. Surprisingly, the percent recapture for gillnets (25%) was much greater than percent recapture for rod and reel (2%) or longline (<2%) in the CSTP data for Gulf blacktip sharks.

Blacktip shark events are shown by sex in Figures 5, 6, and 7. Males have not been tagged in certain offshore areas off Florida and Texas, as well as large sections of Tamaulipas and Veracruz. However, this trend most likely represents a lack of data from these areas; males are reported to outnumber females in Mexican artisanal fisheries catch (Castillo-Géniz et al. 1998). Sexual segregation in blacktip sharks has been suggested by the work of Dudley and Cliff (1993) and Dodrill (1977). Further work is needed to determine if sexual segregation can be inferred from the CSTP data.

Blacktip shark events are shown by life stage in Figures 8-10. Larger sharks are found in both nearshore and continental shelf waters (within the 200 m depth contour). However, young of the year are almost exclusively found close to shore. These data further support the idea that blacktip shark juveniles spend the first few months of their lives close to shore (Castro 1993, Heupel and Simpfendorfer 2002, Heupel et al. 2007).

Figures 11-13 display the locations of sharks that are young of the year, pregnant, or where embryos were taken from pregnant females. Young of the year are present along most of the U. S. Gulf of Mexico coastline, with exceptions in parts of Florida and Louisiana. This trend may simply reflect reduced effort in these areas. Almost all of these sharks were caught near the shore. Two young of the year were found very

close to the 200 m depth contour off the Florida Keys. However, these young of the year were still relatively close (<15 nautical miles) to land.

Recaptured sharks are shown in Figures 14-16. None of the Gulf of Mexico blacktip sharks migrated out of the Gulf to the Caribbean or Atlantic. CSTP data continue to support the decision to manage the Gulf of Mexico and Atlantic blacktip sharks as two separate stocks (SEDAR11 2006).

Genetic data suggest that the east and west Gulf of Mexico contain two separate populations of blacktip sharks (Keeney et al. 2005). CSTP data showed no movements between the eastern and western Gulf of Mexico, using a boundary of approximately 90°W longitude. The CSTP database did show an exchange between western Gulf waters of the U.S. and Mexico. Blacktip sharks (n=35) migrated south from the waters of Texas and Louisiana to Tamaulipas, Veracruz, Tabasco, and Campeche. Most (n=33) of these recaptures occurred over a period of less than one year, and the shortest such migration was 103 nautical miles in 11 days.

Figures 17-19 display the recapture data by sex and life stage. Thirty-two of the 131 tagged sharks were recaptured in an older life stage than tagged, while the majority of sharks were recaptured within the same life stage. Sharks of all three life stages migrated from U. S. to Mexican waters in the Gulf of Mexico.

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Table 1. CSTP data distribution by sex and life stage for blacktip sharks tagged in the Gulf of Mexico, including all recaptures. YOY=young of the year

Sex	Mature	Juveniles	YOY	Embryos*	Unknown Maturity	Total	Fork Length (cm)				
							Min	Max	Median	Mean	SD
Male	<b>363</b>	<b>640</b>	<b>427</b>	<b>1</b>	<b>4</b>	<b>1435</b>	33	183	74	80.4	29.5
	7.99	14.08	9.39	0.02	0.08	31.57					
	25.30	44.60	29.76	0.07	0.28						
	27.65	29.14	44.25	14.29	6.25						
Female	<b>838</b>	<b>1330</b>	<b>431</b>	<b>4</b>	<b>4</b>	<b>2607</b>	29	190	99	96.1	34.1
	18.44	29.26	9.48	0.08	0.08	57.36					
	32.14	51.02	16.53	0.15	0.15						
	63.82	60.56	44.66	57.14	6.25						
Unknown Sex	<b>112</b>	<b>226</b>	<b>107</b>	<b>2</b>	<b>56</b>	<b>503</b>	32	166	88	88.8	33.4
	2.46	4.97	2.35	0.04	1.23	11.07					
	22.27	44.93	21.27	0.40	11.13						
	8.53	10.29	11.09	28.57	87.50						
Total	<b>1313</b>	<b>2196</b>	<b>965</b>	<b>7</b>	<b>64</b>	<b>4545</b>	29	190	89	90.4	33.4
	28.89	48.32	21.23	0.15	1.41	100					

\*embryos, from captured pregnant females, that were tagged and released

Key

<b>Frequency</b>
<i>Percent</i>
<i>Row Percent</i>
<i>Column Percent</i>



Table 2. CSTP recapture statistics by sex for blacktip sharks tagged in the Gulf of Mexico. Displacement and speed values are calculated using the straight line distance from the tagging location to the recapture location.

Sex	Tagged	Recaptured	Recapture Rate	Mean Displacement (nm)	Max Displacement (nm)	Mean Time at Liberty (days)	Max Time at Liberty (days)	Mean Speed (nm/day)	Max Speed (nm/day)
Male	1386	49	3.5	86.6	584	255.2	1591	1.0	14.2
Female	2539	68	2.7	155.2	632	256.2	2845	2.6	16.4
Unknown	490	13	2.7	109.5	607	249.6	2050	1.5	9.1
Total	4415	130	3.0	123.0	632	253.1	2845	1.9	16.4

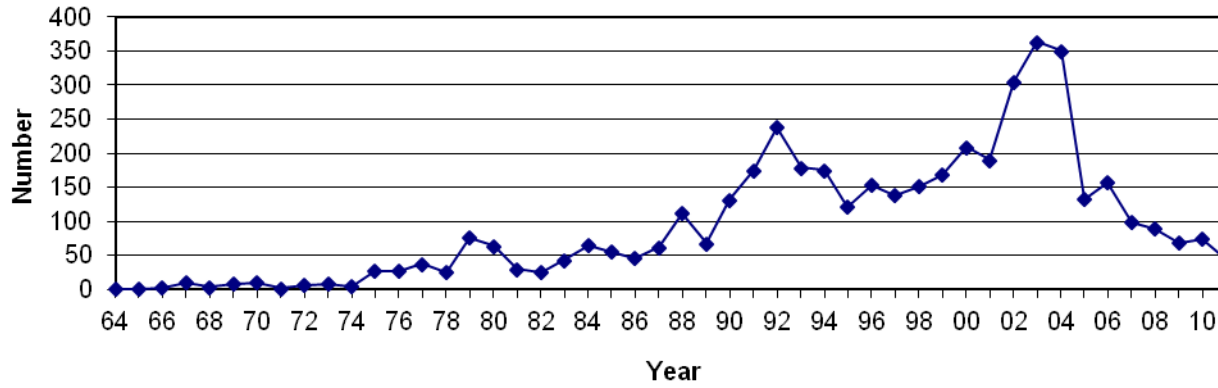
Table 3. Literature values for lengths associated with maturity within the Gulf of Mexico

Reference	n	Location	Condition	Female FL*	Male FL*
Castillo-Géniz et al. (1998)	N/A	Mexico	Minimum size at maturity	-	103.6
			Smallest pregnant female	120.3	-
Branstetter (1986)	N/A	TX	Mature	128.7-132.9	112.0
Branstetter (1987)	60	TX	Smallest mature	-	107.0
			Largest immature	126.2	106.1
			Mature	124.5-128.7	107.8
Carlson et al. (2006)	628	FL	Smallest mature	109	102
			Median length at maturity	117.3	103.4
			Largest immature	122	106
Killam and Parsons (1989)	218	FL	Mature	131.2-134.6	110.3-112.8

\* Values given in TL were converted to FL using formula from Carlson et al. 2006.

A.

Number of Blacktip Sharks Tagged by Year



B.

Number of Blacktip Sharks Recaptured by Year

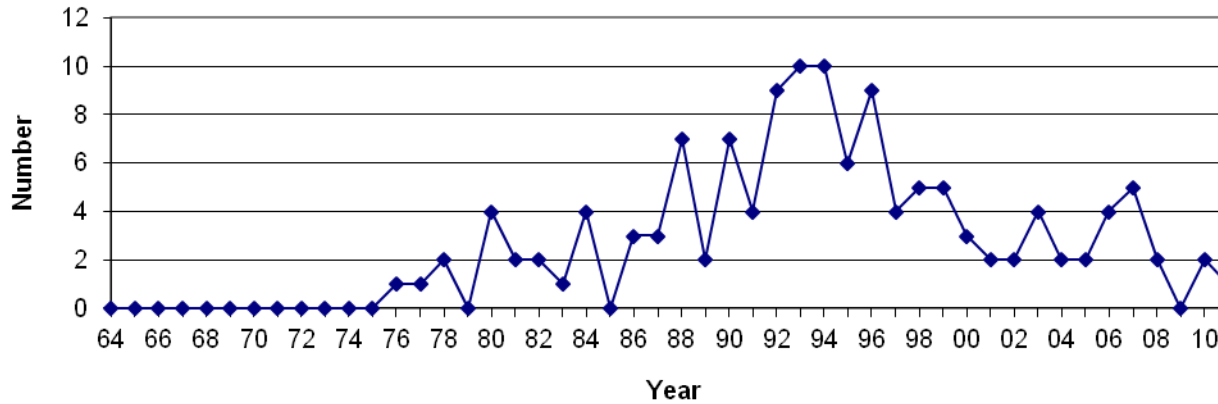


Figure 1. Total number of blacktip sharks tagged (A) and recaptured (B) in the Gulf of Mexico by year.

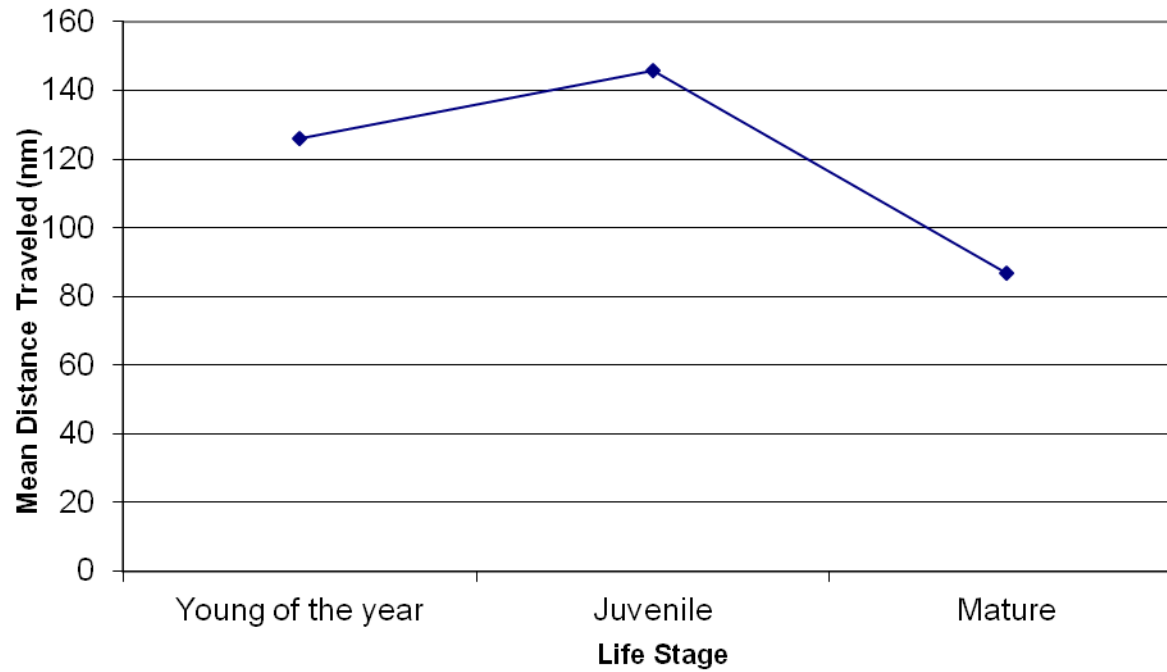


Figure 2. Mean displacement of blacktip sharks at large for 20-365 days. N=34, 33, and 9 for young of the year, juveniles, and mature sharks, respectively. Displacement values are calculated using the straight line distance from the tagging location to the recapture location.

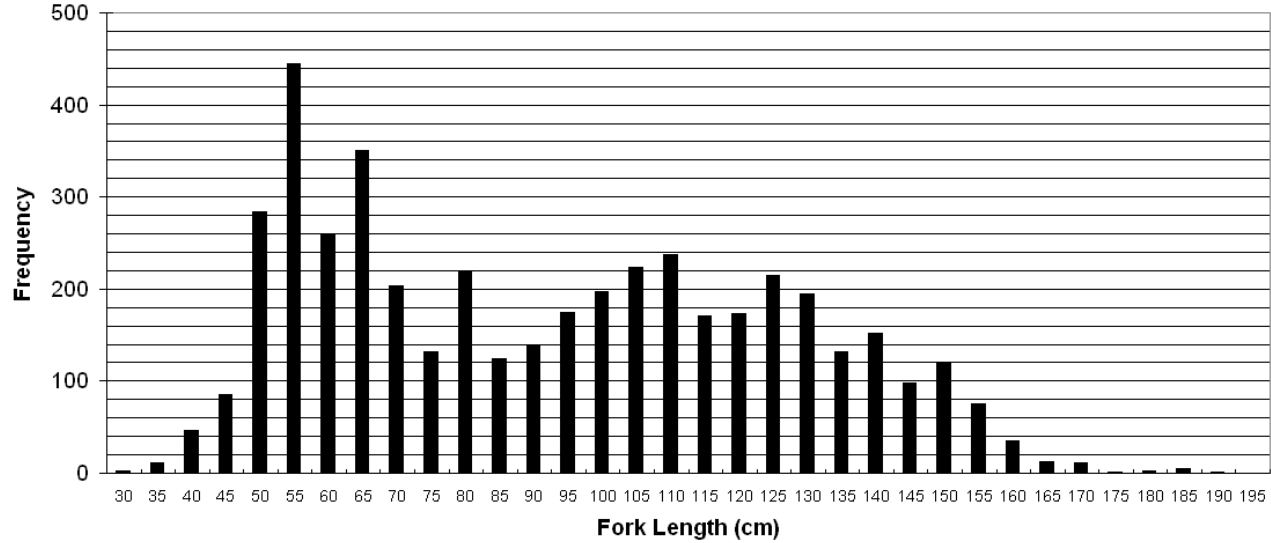


Figure 3. Length frequency for blacktip sharks tagged in the Gulf of Mexico, including recapture data.

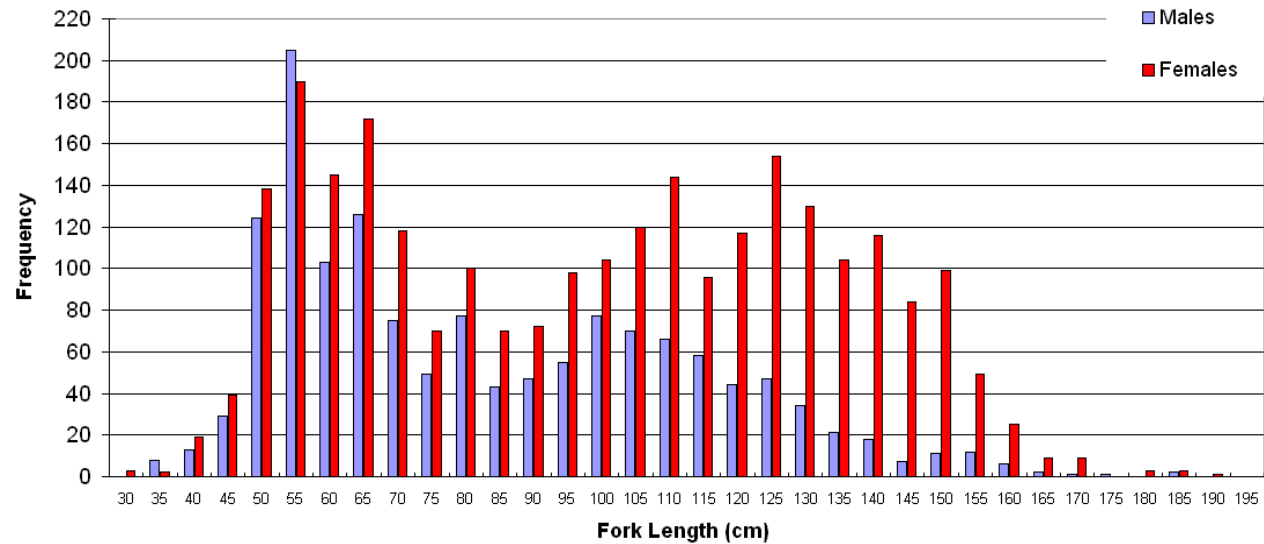


Figure 4. Length frequency by sex for blacktip sharks tagged in the Gulf of Mexico, including recapture data.

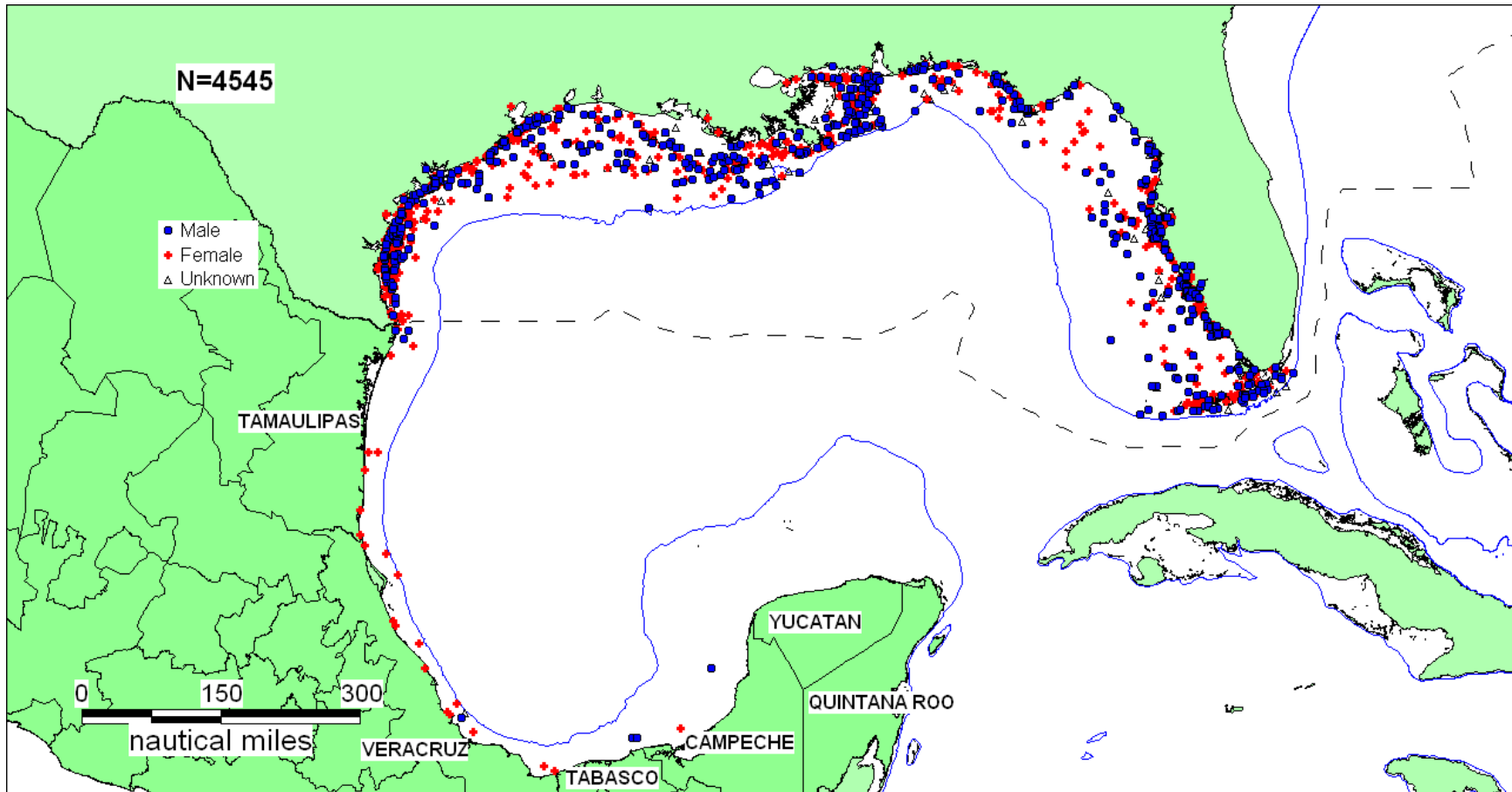


Figure 5. Blacktip shark tagging data by sex, including recaptures. The solid line represents the 200 m depth contour. The dashed line represents the U.S. EEZ.

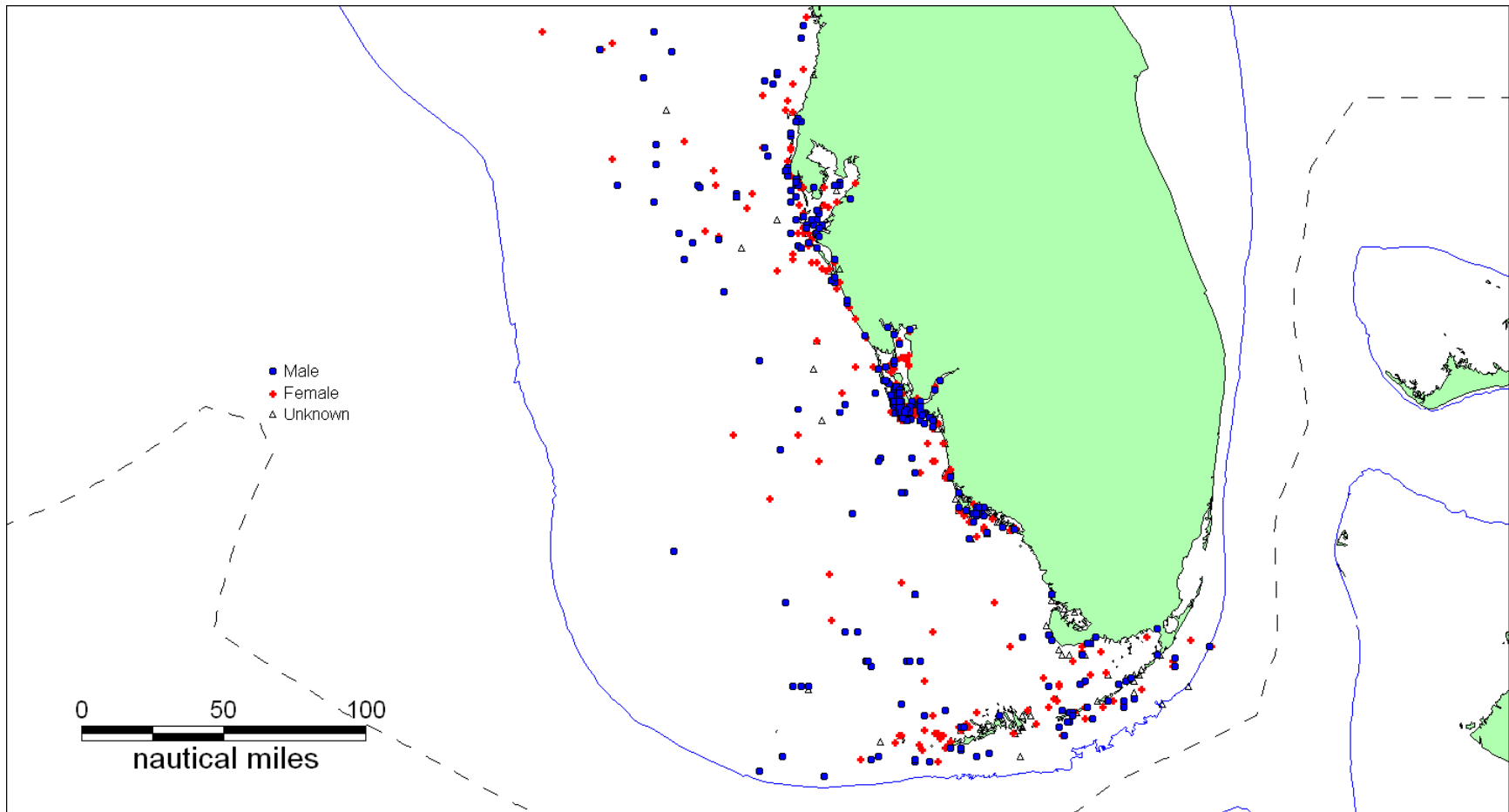


Figure 6. Blacktip shark tagging data (including recaptures) off the west coast of Florida by sex. The solid line represents the 200 m depth contour. The dashed line represents the U.S. EEZ.

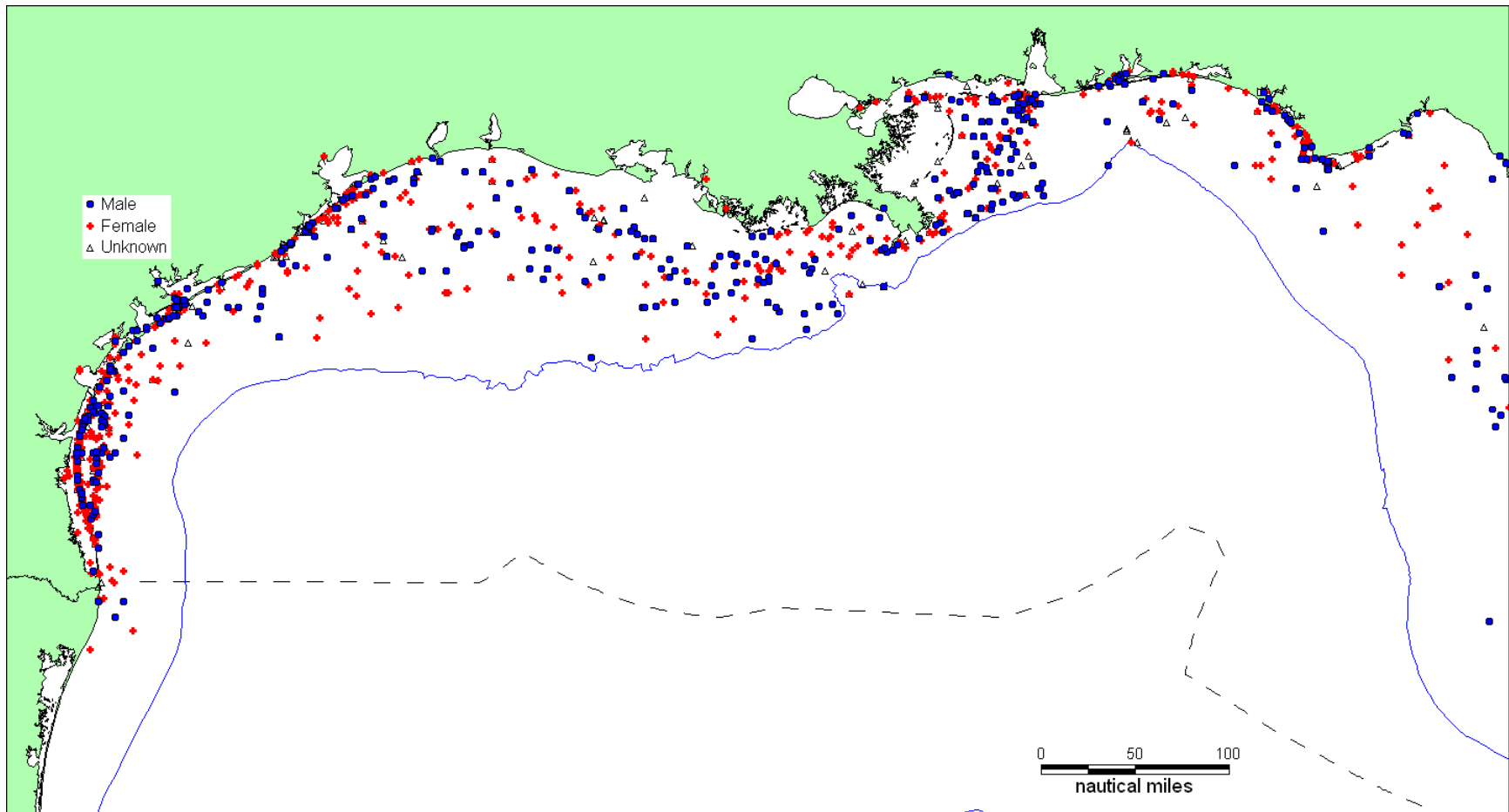


Figure 7. Blacktip shark tagging data (including recaptures) in the northwestern Gulf of Mexico by sex. The solid line represents the 200 m depth contour. The dashed line represents the U.S. EEZ.

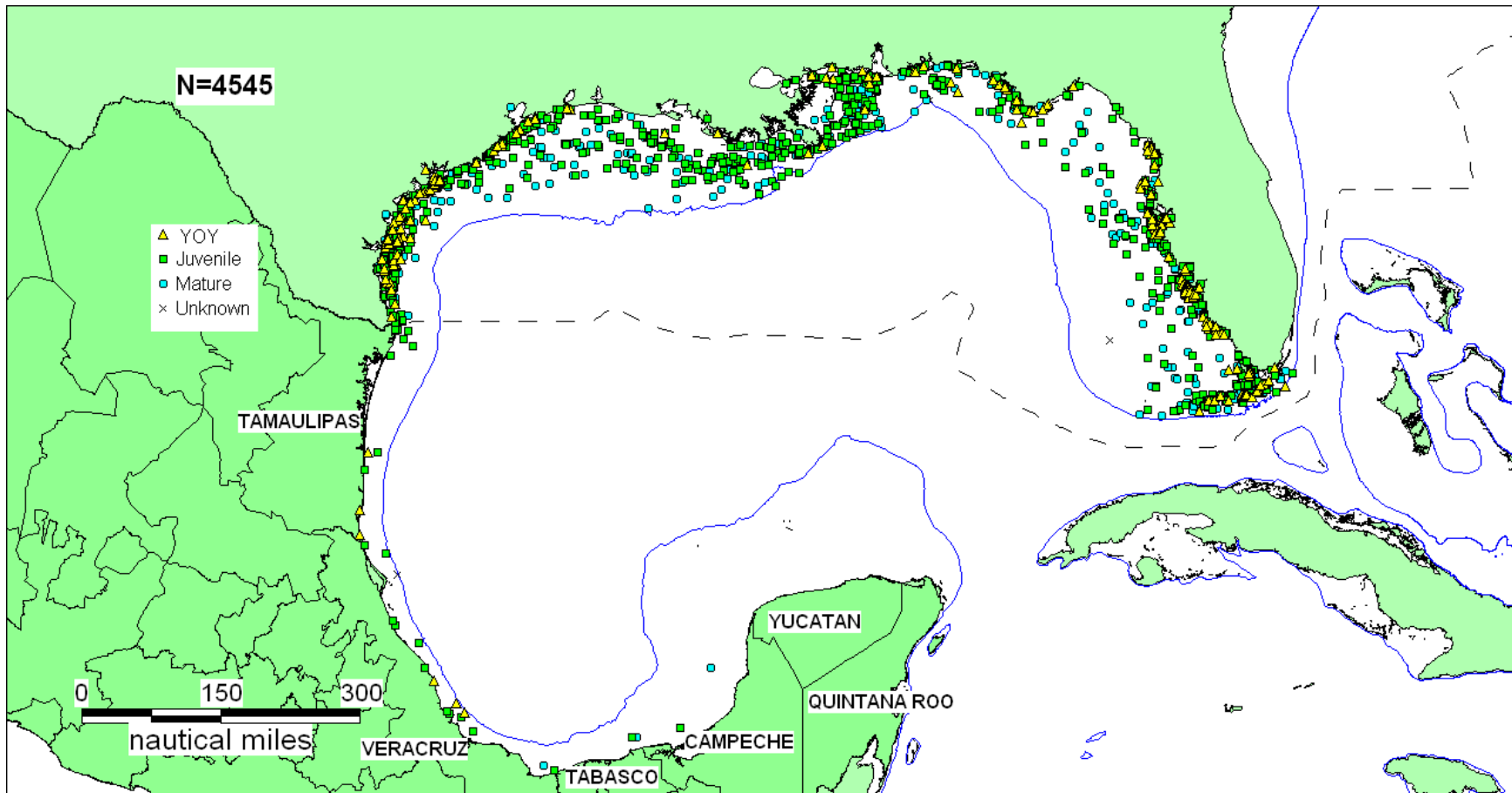


Figure 8. Blacktip shark tagging data (including recaptures) by life stage. The solid line represents the 200 m depth contour. The dashed line represents the U.S. EEZ.



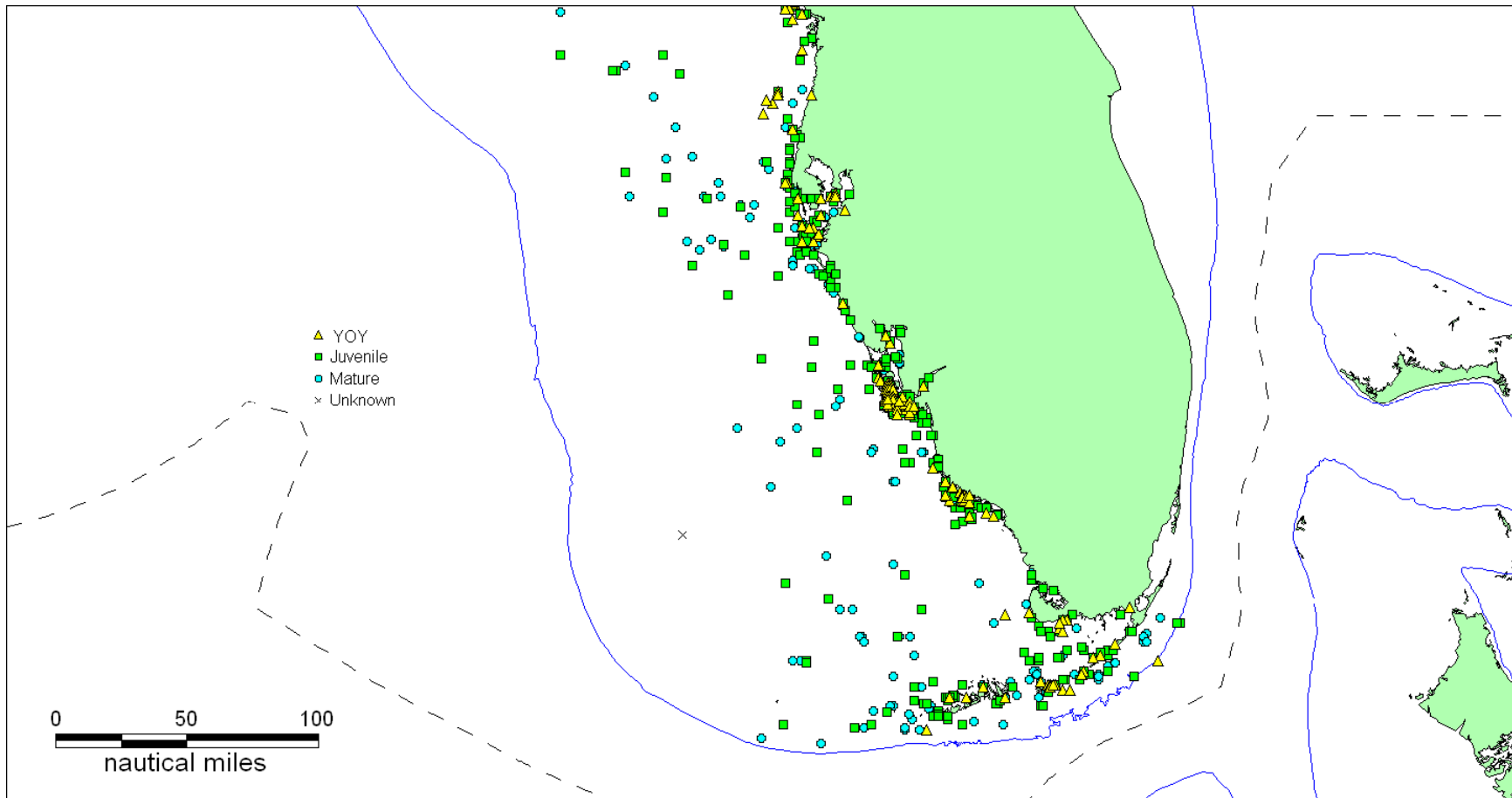


Figure 9. Blacktip shark tagging data (including recaptures) off the west coast of Florida by life stage. The solid line represents the 200 m depth contour. The dashed line represents the U.S. EEZ.

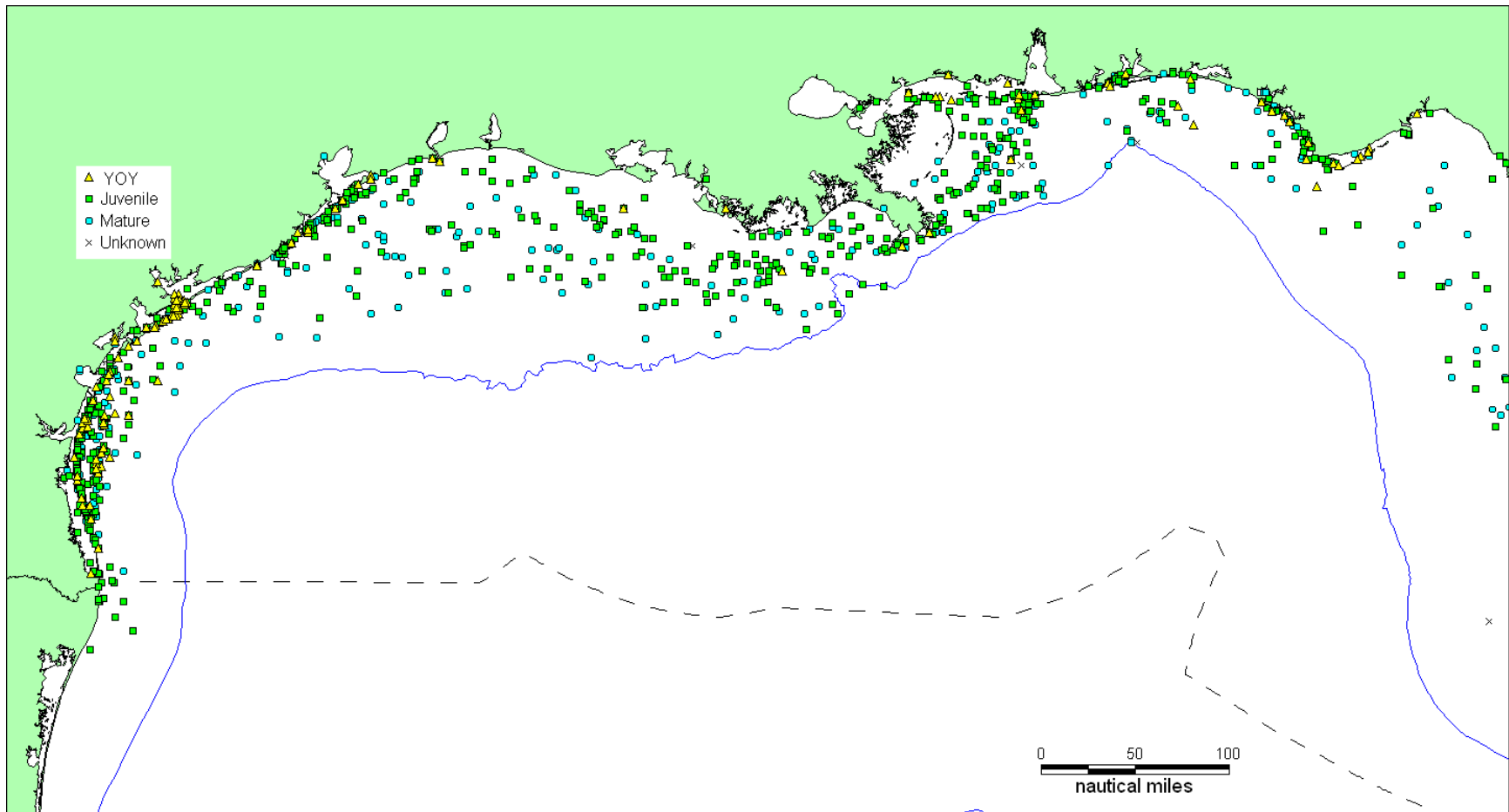


Figure 10. Blacktip shark tagging data (including recaptures) in the northwestern Gulf of Mexico by life stage. The solid line represents the 200 m depth contour. The dashed line represents the U.S. EEZ.

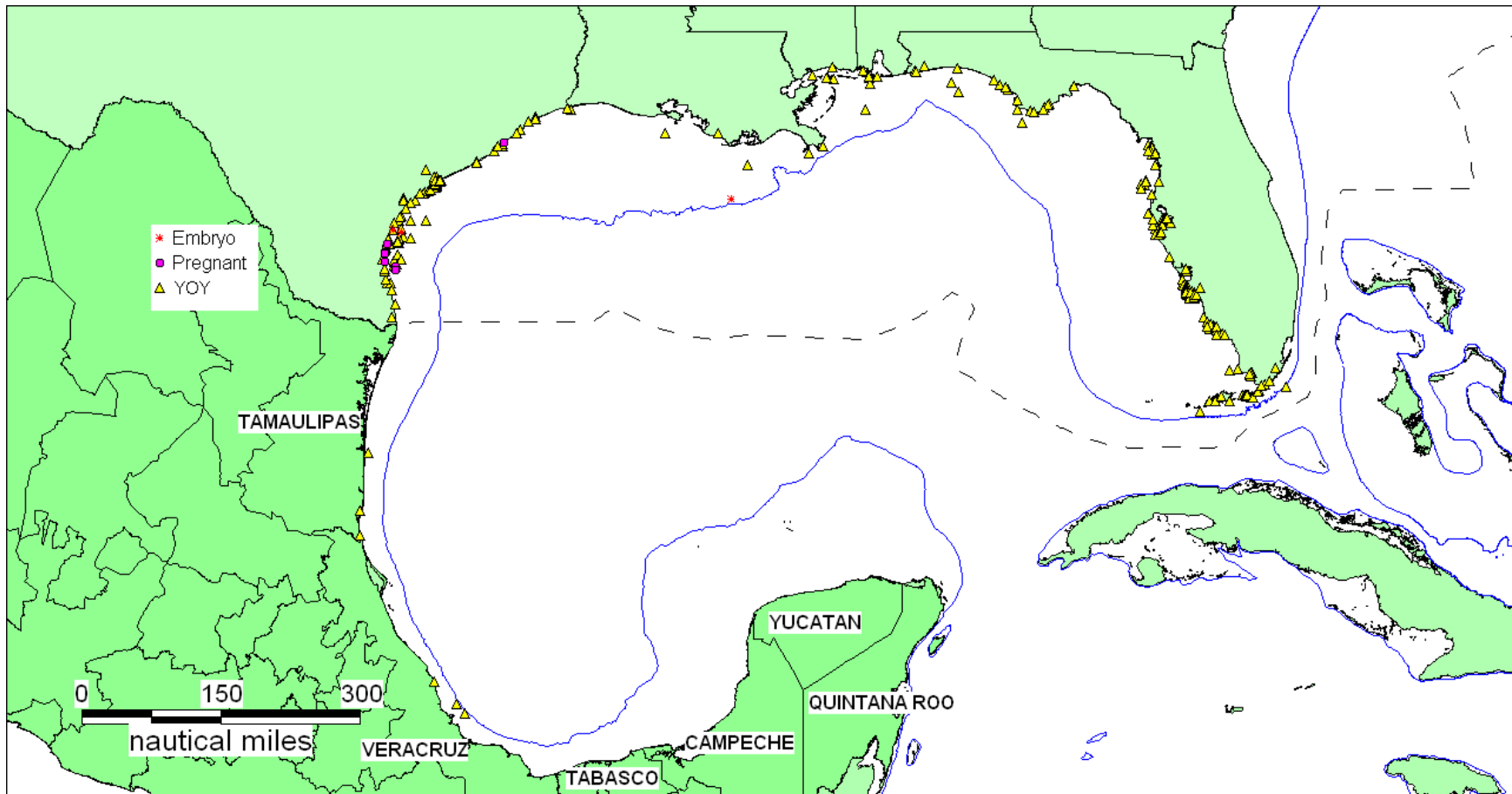


Figure 11. Locations of tagged embryo (indicating captures of pregnant females), young of the year, and pregnant blacktip sharks, including recapture data. The solid line represents the 200 m depth contour. The dashed line represents the U.S. EEZ.

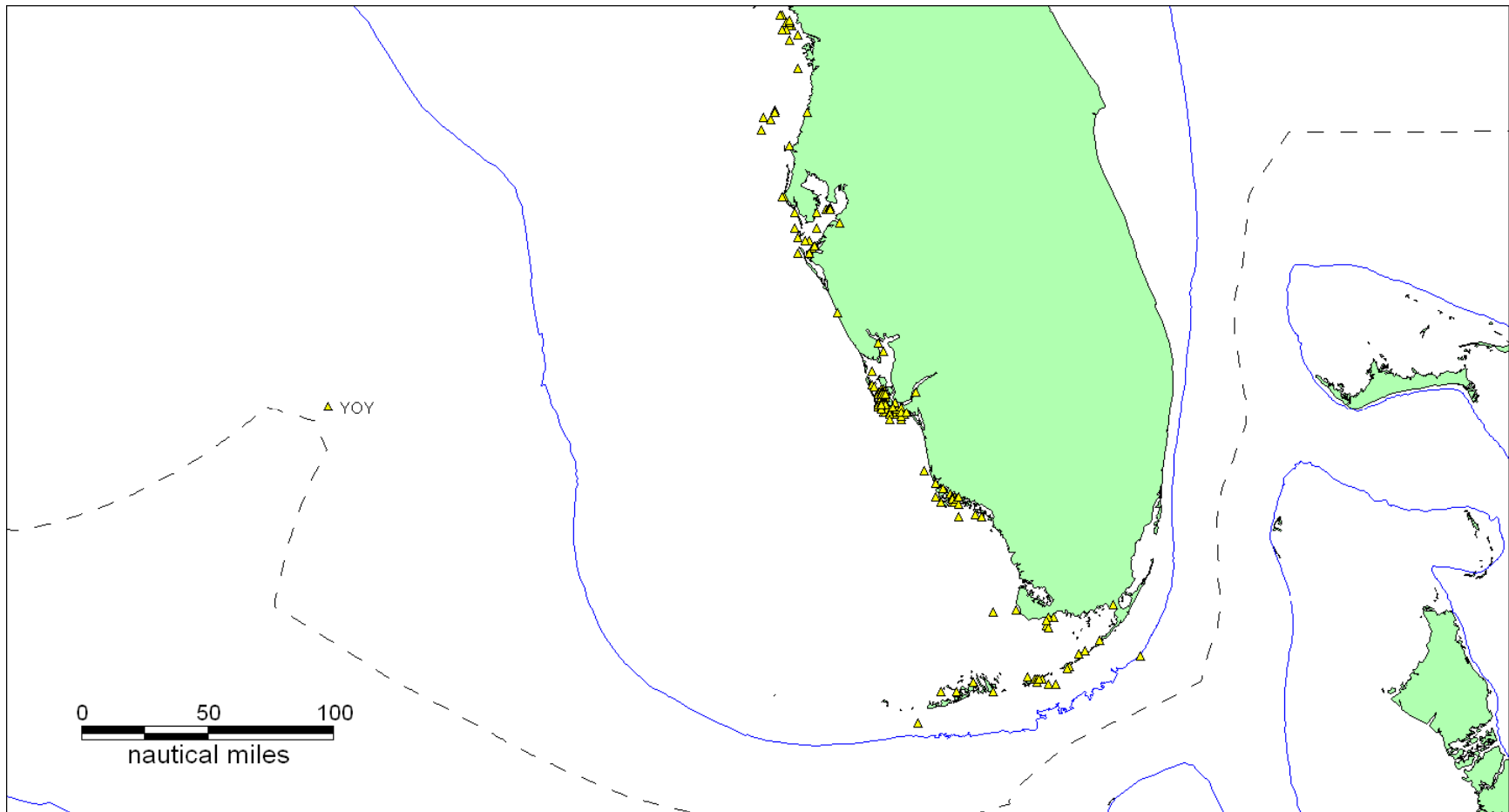


Figure 12. Locations of tagged young of the year blacktip sharks off the west coast of Florida, including recapture data. The solid line represents the 200 m depth contour. The dashed line represents the U.S. EEZ.

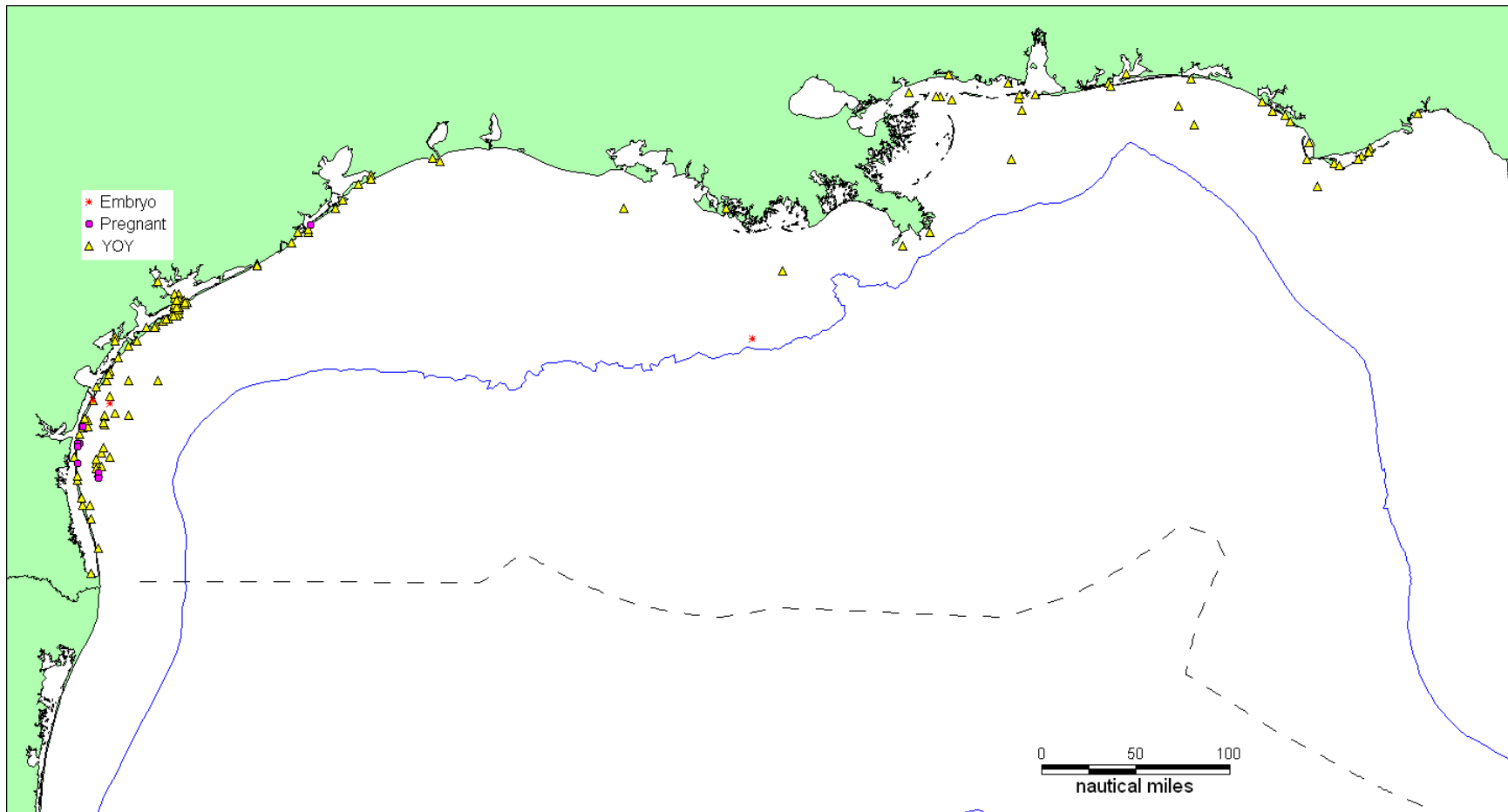


Figure 13. Locations of tagged embryo (indicating capture locations of pregnant females), young of the year, and pregnant blacktip sharks in the northwestern Gulf of Mexico, including recapture data. The solid line represents the 200 m depth contour. The dashed line represents the U.S. EEZ.

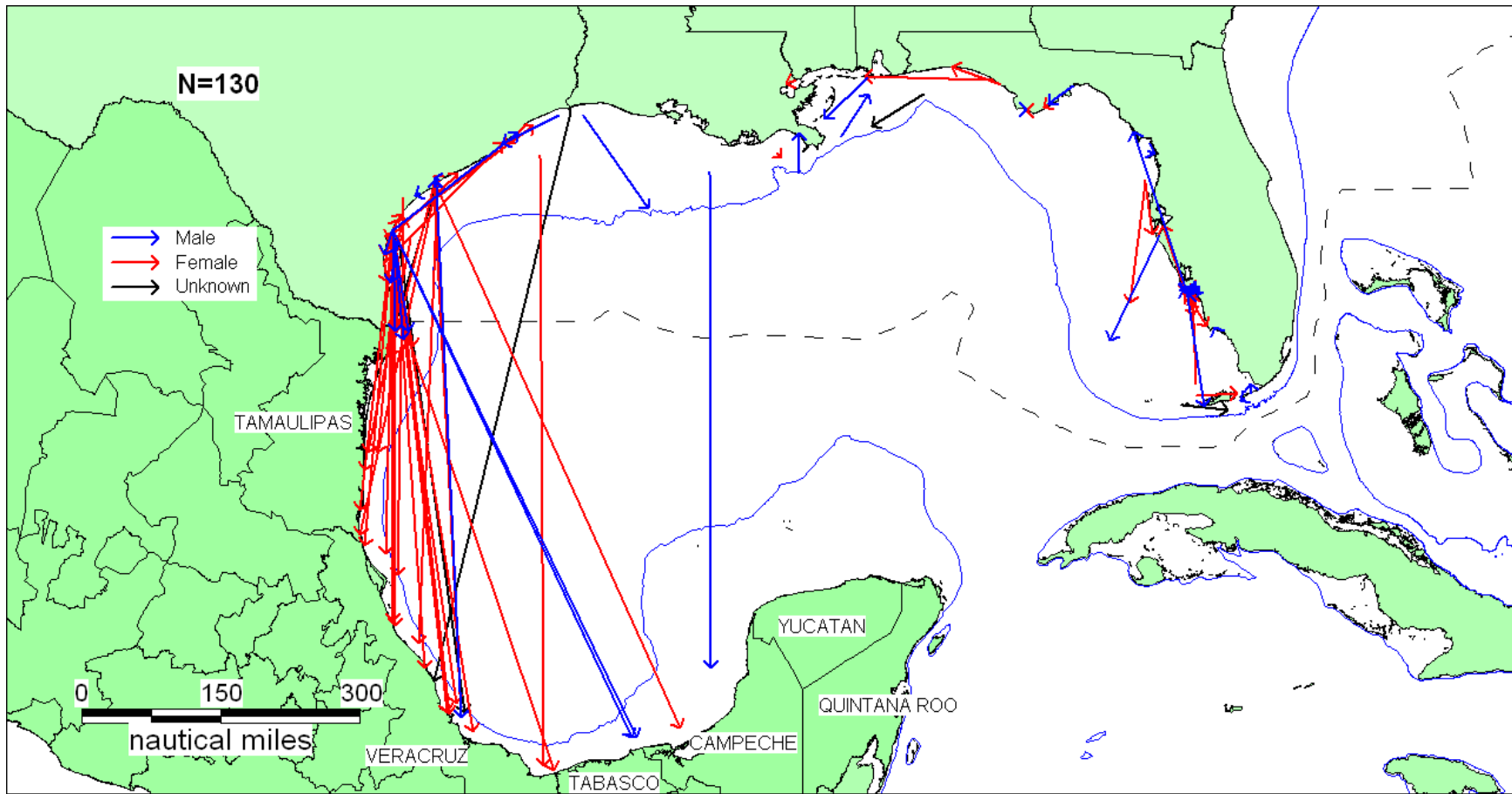


Figure 14. Blacktip shark recaptures by sex. The solid line represents the 200 m depth contour. The dashed line represents the U.S. EEZ.

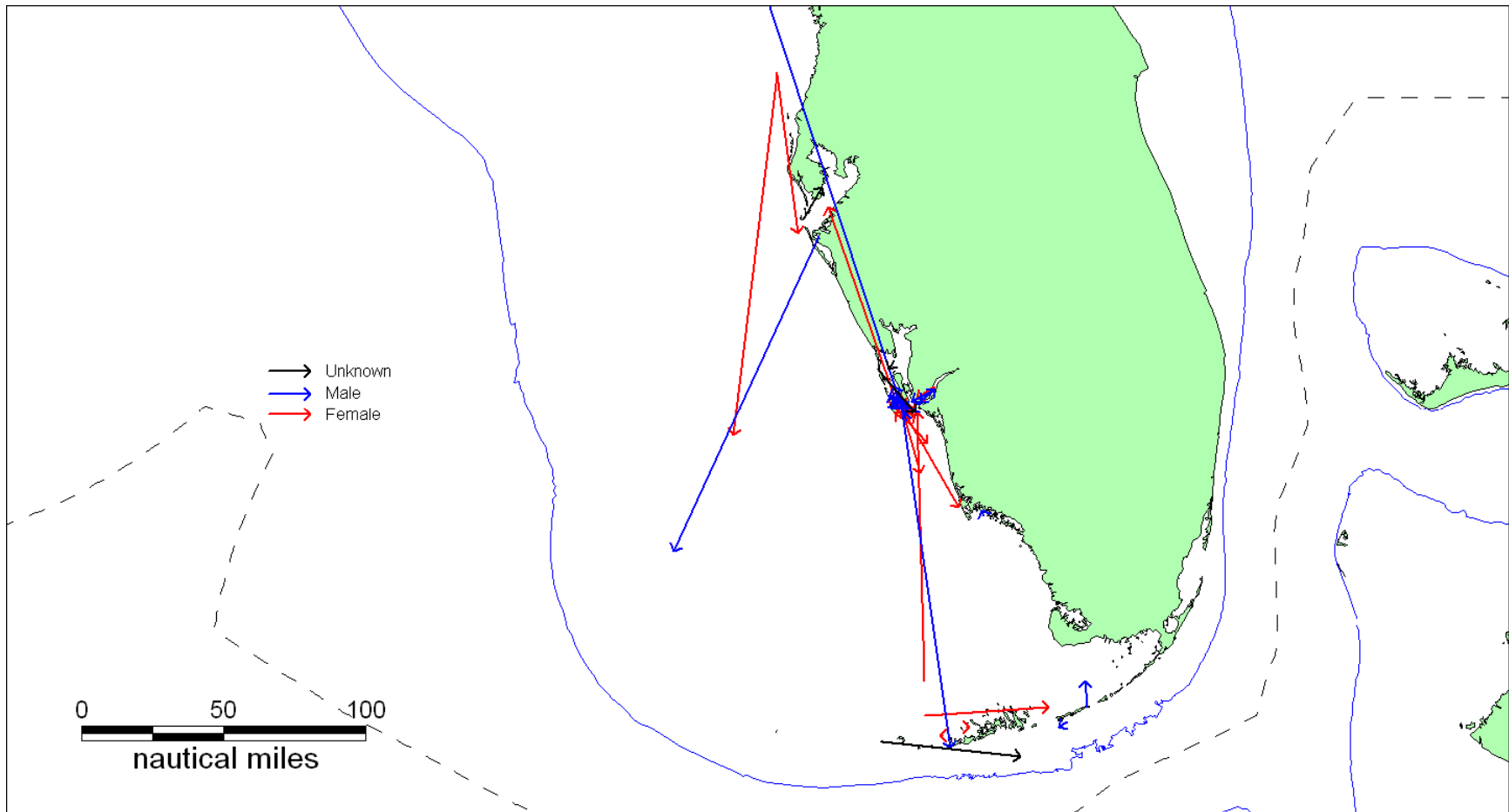


Figure 15. Blacktip shark recaptures off the west coast of Florida by sex. The solid line represents the 200 m depth contour. The dashed line represents the U.S. EEZ.

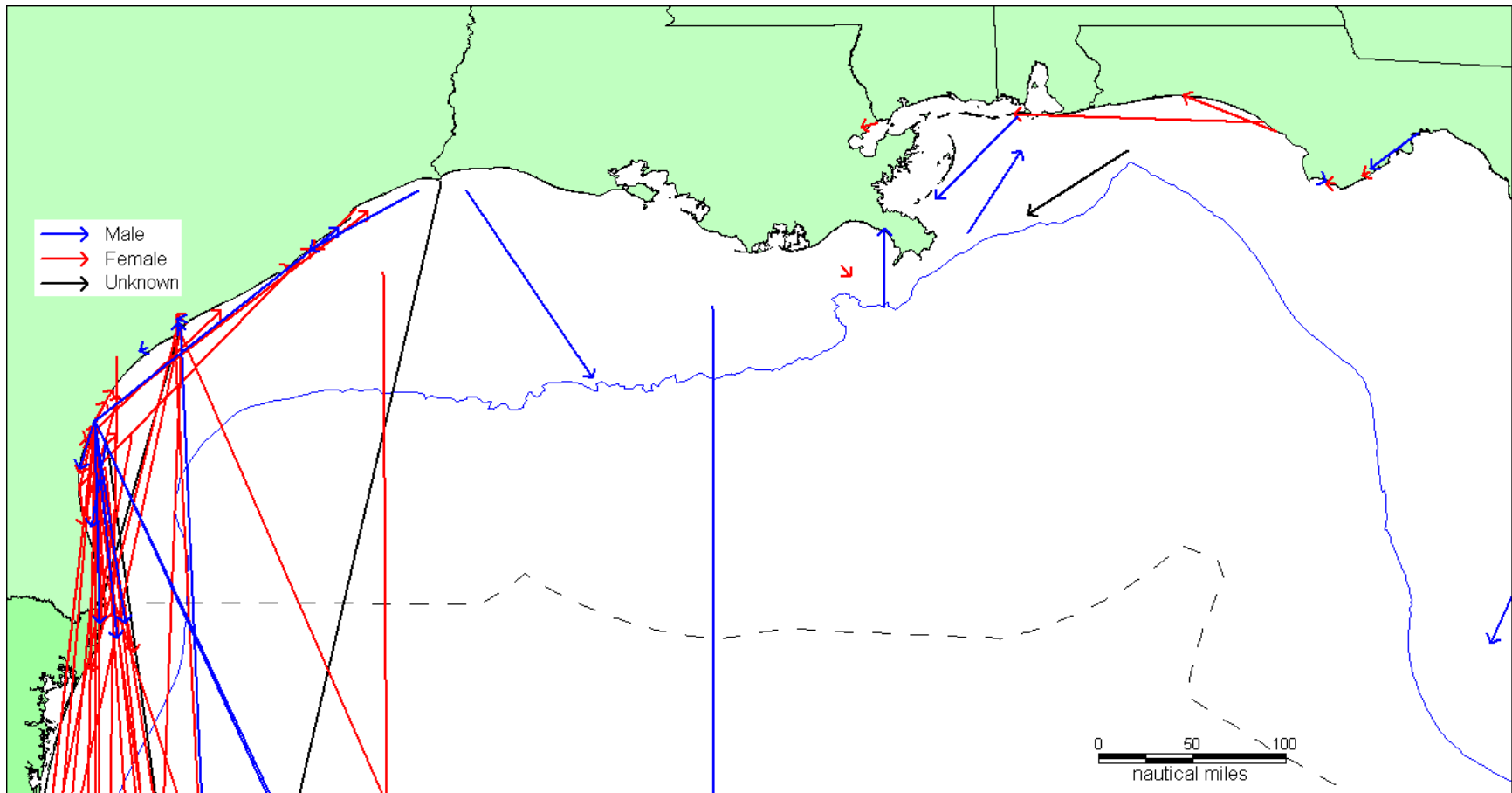


Figure 16. Blacktip shark recaptures in the northwestern Gulf of Mexico by sex. The solid line represents the 200 m depth contour. The dashed line represents the U.S. EEZ.



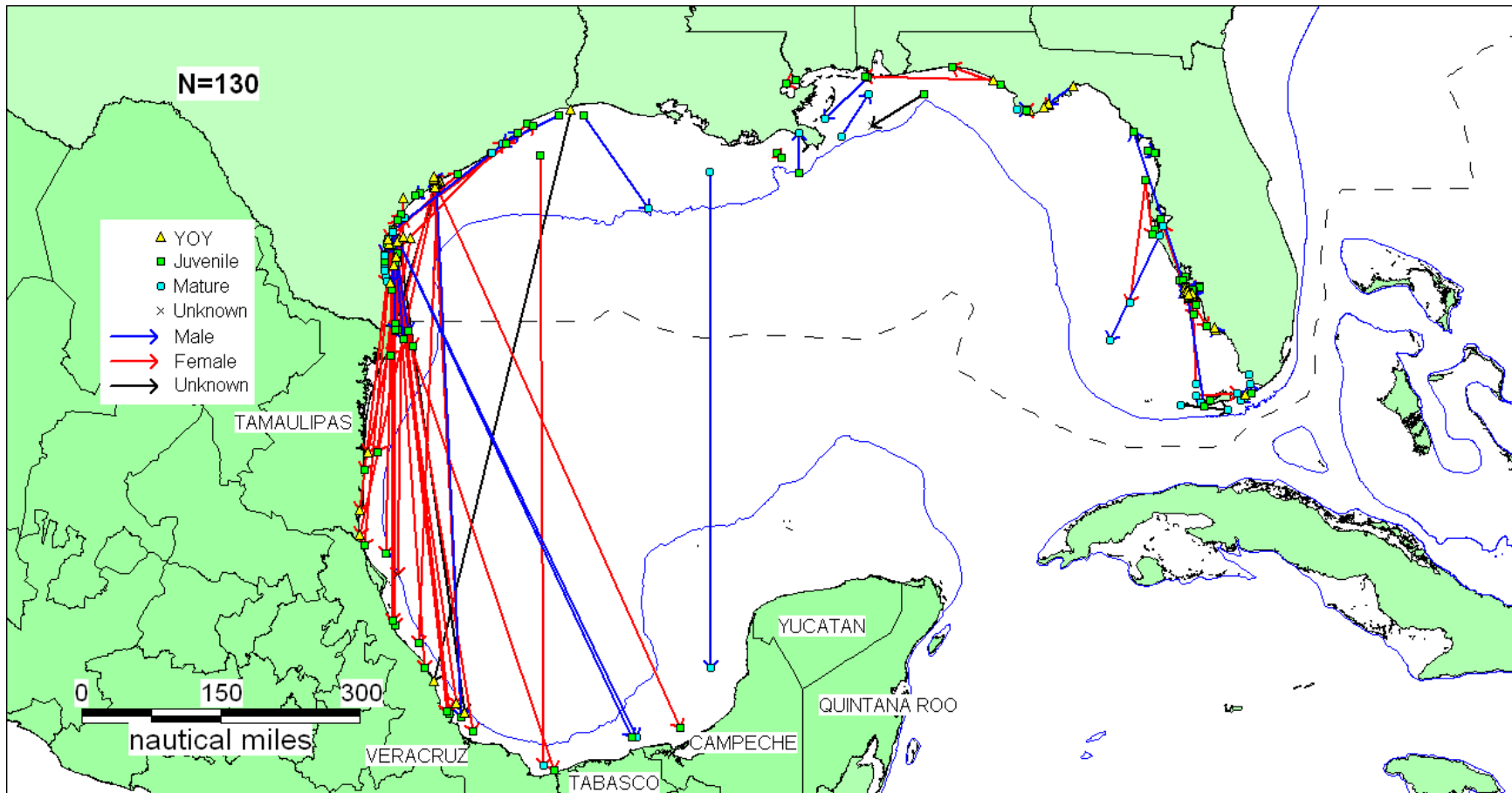


Figure 17. Blacktip shark recaptures by sex and life stage. The solid line represents the 200 m depth contour. The dashed line represents the U.S. EEZ.

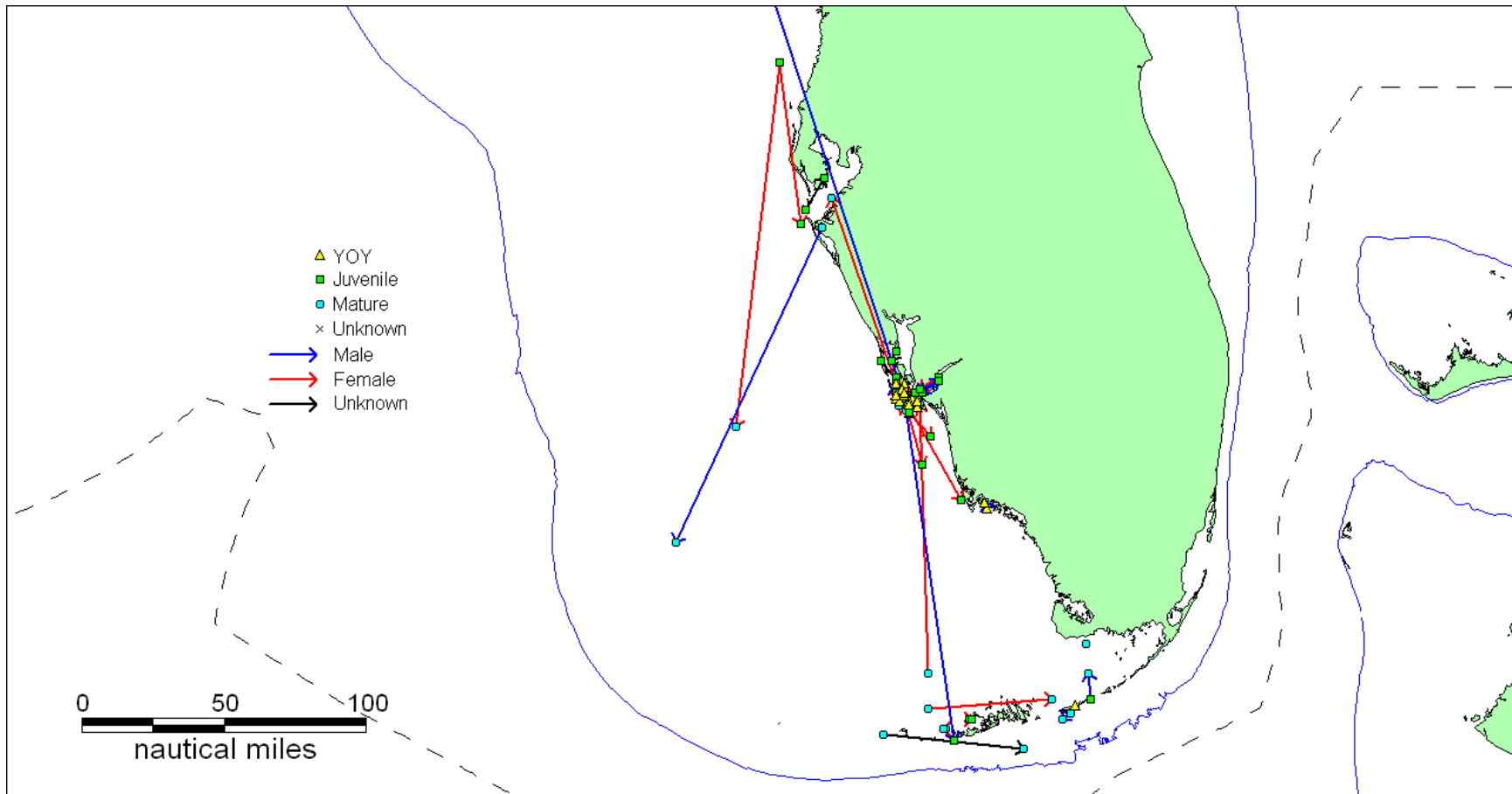


Figure 18. Blacktip shark recaptures off the west coast of Florida by sex and life stage. The solid line represents the 200 m depth contour. The dashed line represents the U.S. EEZ.

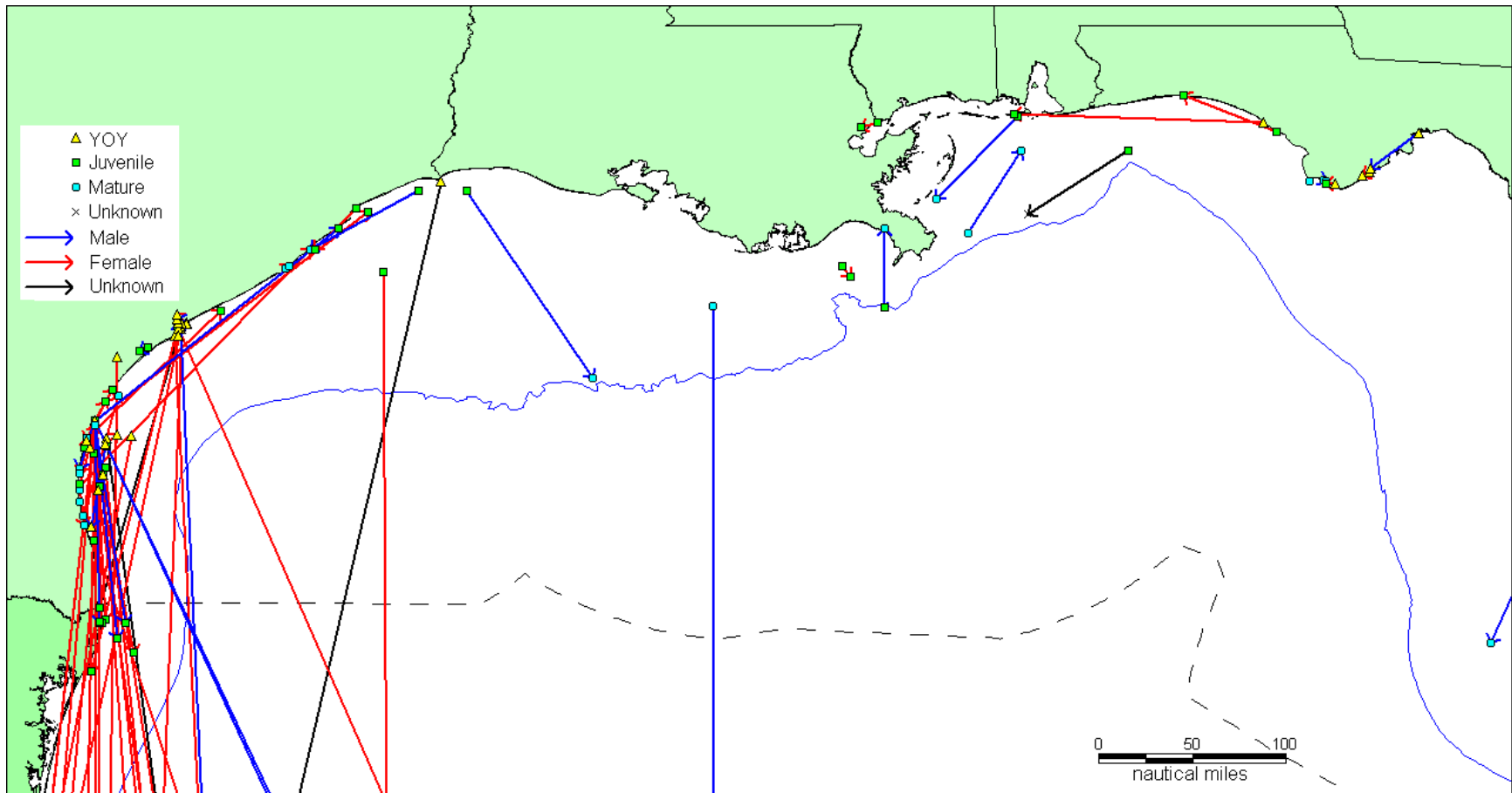


Figure 19. Blacktip shark recaptures in the northwestern Gulf of Mexico by sex and life stage. The solid line represents the 200 m depth contour. The dashed line represents the U.S. EEZ.