Northeast Fisheries Science Center Reference Document 07-07

Evaluation of a Modified Scallop Dredge's Ability to Reduce the Likelihood of Damage to Loggerhead Sea Turtle Carcasses

by Henry O. Milliken, Lisa Belskis, William DuPaul, Jeff Gearhart, Heather Haas, John Mitchell, Ron Smolowitz, and Wendy Teas

April 2007

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Abstract

In 2003 and 2004 the scallop industry, Coonamessett Farm, and the Virginia Institute of Marine Fisheries, with funding from the NOAA Fisheries Service, successfully tested a series of chains that excluded turtles from entering the dredge bag. After further consultation with the Northeast Fisheries Science Center and with additional funding, Coonamessett Farm was awarded a contract to redesign the dredge frame to reduce the probability of a turtle on the seafloor going under the dredge frame. In collaboration with the Harvesting Systems and Engineering Branch of NOAA Fisheries Service, divers videoed the results of placing turtle carcasses in the path of a modified scallop dredge. Twelve trials were completed, and turtle carcasses went over the dredge in all but three trials. Damage was assessed as "slight or none" in all valid assessments of damage to a carcass following an encounter.

Introduction

Sea scallop dredge gear fished in the mid-Atlantic region incidentally captures sea turtles (Murray 2004a, 2004b, 2005, 2007). NOAA National Marine Fisheries Service's (NMFS) Northeast Fisheries Science Center (NEFSC) has been working collaboratively with the scallop industry, Coonamessett Farm, Virginia Institute of Marine Science (VIMS), and the Southeast Fisheries Science Center (SEFSC) to mitigate the bycatch of sea turtles in the sea scallop dredge fishery. A study with twenty-two experimental cruises and 3,248 paired hauls assessed the effectiveness of "turtle chains" affixed to sea scallop dredge gear in reducing sea turtle bycatch (DuPaul et al. 2004). On August 25, 2006, NMFS issued a final rule to require sea scallop dredge vessels fishing south of 41°9.0′ N. latitude May 1–November 30 each year for dredges to be equipped with turtle chains (NMFS 2006).

Despite the implementation of the chain mat rule, there is concern that some turtles may sustain injuries if they encounter the dredge on the seafloor and go under the dredge. Questions have also been raised about injuries turtles might sustain if, after they interacted with the dredge, they go over the dredge rather than under the cutting bar.

In response to these concerns, the NEFSC funded the development of a modified dredge designed to act as a wedge and guide turtles over the top of the dredge. A prototype was evaluated in 2005 in Panama City FL using fiberglass turtles and turtle carcasses. This work achieved some success at increasing the probability of turtle carcasses going over the dredge as opposed to under the cutting bar, and resulted in several ideas for additional modifications.

This report summarizes (1) the gear modifications that occurred after the 2005 Panama City gear trials, (2) the 2006 Panama City gear trials, (3) the documentation of damage that occurred to turtle carcasses after interacting with the redesigned dredge, and (4) suggestions for future study.

Methodology

The primary objectives of this project were to (1) modify the 2005 prototype dredge, (2) provide qualitative assessments of the efficacy of the modified scallop dredge to cause turtle carcasses to go over the dredge while fishing on the seafloor, and (3) document any carcass damage associated with such interactions.

Modifications to the Dredge Design

As a result of the 2005 testing, a new modified dredge prototype was conceived and constructed under contract to Coonamessett Farm for evaluation during 2006. The experimental dredge was a modification of a standard New Bedford style sea scallop dredge (Figure 1A). The modifications consisted of moving the cutting bar forward, removing all brace bars in the bale section, and adding several vertical round stock bars along the face of the dredge between the depressor or "pressure" plate and the cutting bar (Figure 1B). Moving the cutting bar forward changes the geometry of the dredge frame, and the new wedge shape was thought to increase the probability of turtles going over the frame rather than under the cutting bar. Removing the brace bars from the bale section eliminates barriers that might hold a turtle under the bale rather than letting it pass through the bale and escape over the dredge frame. The round stock bars were added to keep contact with the seafloor and to add a structure that might help turtles move up and over the cutting bar.

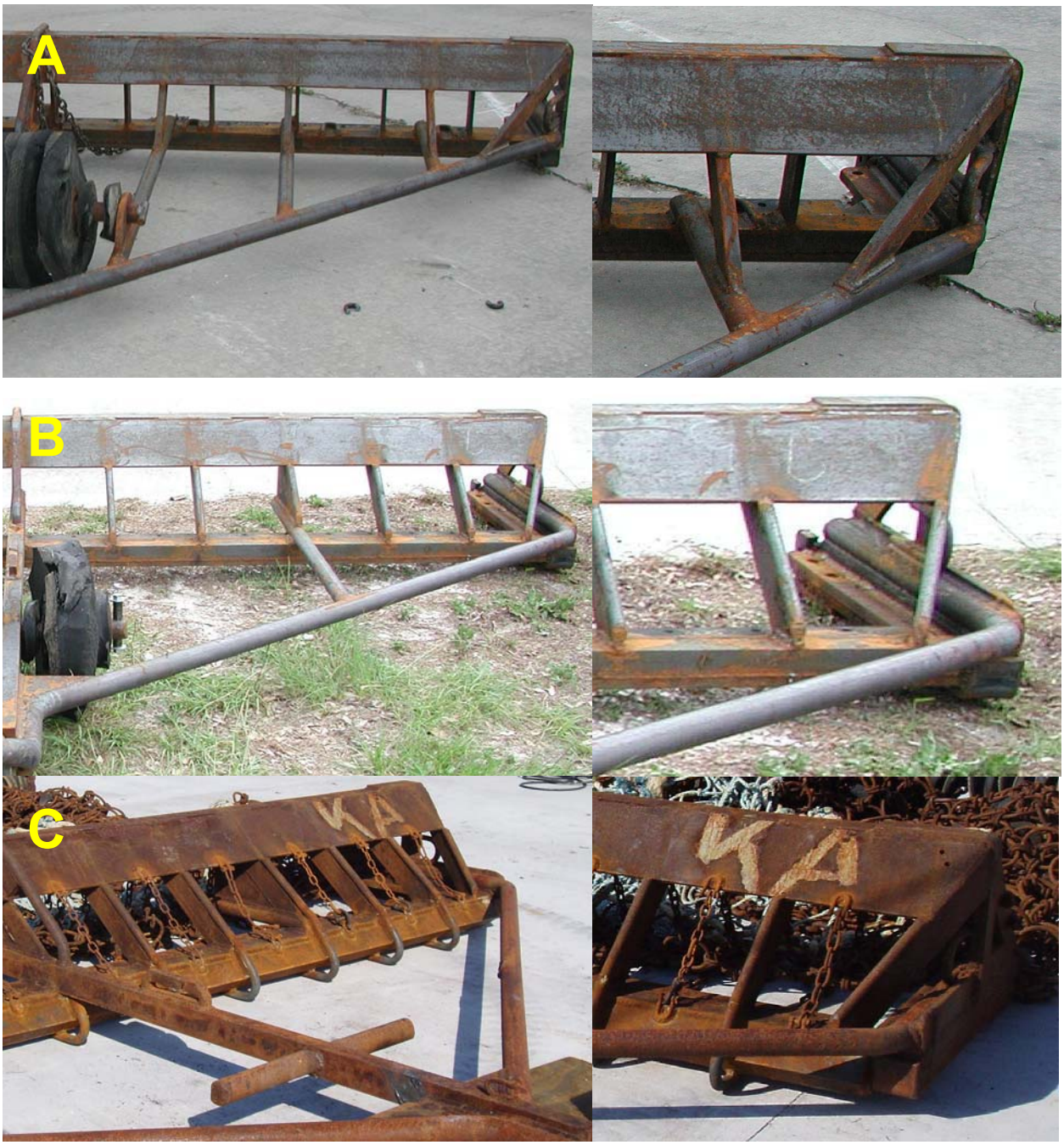

Figure 1. New Bedford style scallop dredge (A) and modified scallop dredge used in 2005 study (B). Modified dredge has cutting bar forward of traditional dredge resulting in a "ramp". (C) Dredge used in 2006 modified by reducing the vertical flat surface of the cutting bar and removal of all bale support bars.

Assessment of modified dredge design

The experiment was designed to simulate the "worst case scenario" of a dredge overtaking and hitting a motionless turtle lying on the bottom. This scenario was achieved by having two NOAA divers place either a turtle carcass or turtle model in the path of the towed dredge. Turtle carcasses were deployed at predetermined locations and orientations along the path of the dredge to help identify potential flaws in the dredge design. Each interaction was

documented by videotaping the event from three different perspectives. The team of divers deploying the turtles videotaped the initial portion of the interaction, while a team of divers on the dredge videotaped the entire interaction. An additional camera was placed at different locations on the dredge bale, depending on the predetermined interaction location, to document the entire tow including the interaction.

Due to time and cost constraints, turtles were not randomly placed in the path of the dredge. Divers were instructed to place turtles in specific predetermined orientations and locations along the face of the dredge in an effort to identify design flaws. Because of the methodology, the ratio of carcasses that went over the dredge might be higher than what was recorded.

This project used the F/V *Capt. Wick*, a 60 gross ton, 65-ft shrimp trawler. The vessel was modified by adding an 'A' frame off the stern of the vessel to tow the 13' modified dredge. This vessel also served as the platform for staging the dive operations while an inflatable boat was used to transport the divers between the vessel and the tow path. Gross necropsies of the turtle carcasses were performed on the vessel, while the finer scale examinations were completed onshore.

Based on preliminary tows to determine optimum scope and towing speed, all tows were conducted using a 3:1 ratio of tow wire to depth and a towing speed at 3.0 knots. This was a compromise to achieve a dredge towing angle that closely matched that of commercial dredges while allowing divers to safely ride the dredge. This speed was slower than typical commercial towing speeds of 4-5 knots.

Assessment of post-interaction damage to the carcass

Five separate turtle carcasses were used in 14 field trails (Table 1). The carcasses were found dead on beaches (stranded) and varied in freshness, size, and levels of emaciation. All of the carcasses were inspected thoroughly prior to deployment to document existing external damage. Placement of turtle carcasses in the path of the dredge was not random. Placement for most trials was predetermined to assess the effectiveness of the design in various areas of the dredge. After each interaction, the carcasses were recovered and damage assessments were performed by trained NMFS staff. Each carcass was used multiple times. A successful deployment was defined as a trial where a carcass was placed in the path of the dredge and the carcass interacted with the dredge. Damage assessments were performed after each interaction between the carcass and the dredge, but only the damage assessment after the first carcass deployment was used to assess potential damage due to gear interactions because the carcasses could become more easily damaged if their structure was compromised during the initial interaction. The fiberglass turtle model (tow 17) used to mimic how a motionless turtle might interact with dredges was of a similar size to turtles incidentally captured by commercial sea scallop dredge vessels, but it had inflexible appendages (head, flippers). Because of the dissimilarities to carcasses, it was not included in the assessments.

Results

Assessment of modified dredge design

Seventeen repeated dredge tows were completed and twelve successful trials were achieved (Appendix 1). Two test tows were used to determine proper towing configuration, two tows failed to interact with the turtle carcass, and one tow used the fiberglass turtle. In eight of

Tow	Disposition	Turtle	Assess	Observed damage	Score of severity
1	No turtle used / video and scope testing	N/A	N/A		
2	No turtle used / video and scope testing	N/A	N/A		
3	Deflected off side	1	Yes	minor abrasions - front flippers	1
4	Up and over side	1	No	no additional damage	1
5	Missed	2	-		
6	Bale held turtle from going over	2	Yes	small crack - marginal; abrasions - flipper, carapace, marginals	1
7	Went over	2	No	part of carapace loose/cracked; abrasions - head, flipper	2
8	Went over	3	Yes	abrasions - head, carapace, marginals	1
9	Missed	4	-		
10	Went over	4	Yes	abrasions - flippers, head, jaw, carapace, marginals	1
11	Bale held turtle from going over	3	No	posterior plastron/carapace broken/missing; abrasions - carapace, flippers	3
12	Went over	4	No	no additional damage	1
13	Went over	4	No	right side carapace bone broken, almost off; crack - posterior carapace	3
14	Went over / trapped[1]	5	Yes	no additional damage	1
15	Went over	5	No	no additional damage	1
16	Bale held turtle from going over	2	No	anterior plastron ripped open, part missing; posterior marginals broken off, side marginals loose; abrasions - head, flippers, carapace	3
17	Head under bale prohibited turtle from moving	Fiberglass	-	Not used for assessment of damage	

Table 1. Listing of damage assessment from all turtle carcasses used in the trials. The "assess" column refers to whether the carcass should be used to assess carcass damage. Carcass damage should only be assessed the first time a carcass is used. The "score of severity" refers to an evaluation of the damage incurred on the carcass. 1 = slight or none, 2 = moderate, 3 = severe. Shading signifies carcasses that can be used for damage assessment.

[1] The turtle carcass had weights attached that may have hung on the face of the dredge preventing it from sliding completely over the dredge. See Appendix 1 for more details.

the twelve trials, the carcasses went over the dredge (n=7) or were deflected to the side (n=1; tow 3). In one of the remaining four trials (tow 14), the turtle carcass was outfitted with weights because it was buoyant, started to go over the dredge but was constrained from passing completely over by the dredge by the weights which caught the frame of the dredge. Additionally, the front flippers may have been caught (see Appendix 1). In the remaining three trials, the bale held the carcass from going over the dredge. There were no instances of any carcass going under the dredge frame.

In addition to the twelve trials with carcasses, one trial (tow 17) used a fiberglass turtle. The fiberglass turtle became trapped under the bale by its rigid flippers (see Figure 12 in Appendix 1). Because of the rigidity of the appendages, it is difficult to infer very much from this interaction.

Assessment of post-interaction damage to the carcass

As previously indicated, damage assessments to the carcasses were limited to the first trial in which the turtle carcass was used, even though turtle carcasses were used multiple times (Tows 3,6,8,10 and 14: Table 1). Each of the five carcasses was successfully deployed in the path of the dredge. Carcass damage from the dredge interaction for each in the five trials was slight or none (Severity score 1: Table 1).

Discussion

The turtle carcass interaction trials should be considered an exploratory scenario; the behavior of a live turtle near a dredge may change the outcome of the interaction. The use of turtle carcasses and a turtle model did not provide information about the behavior of sea turtles around scallop dredges, particularly on how and where (in the water column) interactions occur with the dredge and how turtles may be able to avoid a dredge at or near the bottom.

There are several reasons why it is inappropriate to conclude that the damage to turtle carcasses in this experiment are representative of injuries that result from benthic interactions in the scallop dredge fishery:

- this study used turtle carcasses which could not exhibit any behavioral responses to the dredge
- physical damage to the carcasses in the experiment may have been affected by the level of pre-test decomposition of the carcasses
- carcasses were placed in predetermined locations along the face of the dredge which biases results
- tows were prematurely ended when turtles were trapped under the bail to minimize damage
- the experimental sample size was small

Because of the limitations of using models and turtle carcasses, and conducting the trials in a different geographic area where the fishery interactions occur, this project could not assess how turtles interact with commercial sea scallop dredges. Rather, the goal of this project was to examine how well the modified prototype dredge minimized the impact on motionless turtles interacting with the gear while the dredge was fishing on the seafloor.

The experimental dredge performed well, allowing most carcasses that passed under the bale to be deflected up and over the front of the dredge frame. In the 12 successful interaction

trials, only three turtle carcasses ending up trapped in locations that required removal by divers. However, this outcome should not be interpreted as measure of the dredge design's performance because carcasses were not randomly placed in the path of the dredge. Divers were instructed to place turtles in specific predetermined orientations and locations along the face of the dredge in an effort to identify specific design flaws. Nevertheless, the performance of the experimental dredge design was a substantial improvement over both the traditional New Bedford style dredge and the 2005 modified dredge.

Although the Panama City gear trials indicate that the 2006 dredge design directed more turtles over the dredge than under the cutting bar, there are a few additional gear modifications which could further reduce possible injuries to sea turtles on the seafloor. The dredge design might be improved to reduce the likelihood of turtles getting blocked either under the center bale bar (Tow 16) or under the side bale bars (Tows 6 and 11). Although live turtles trapped in these areas might be able to escape to either side of the obstructing bar, the encounter might increase the likelihood of an injury. The utility of the round bar strut extensions on the front of the cutting bar appeared to be equivocal to the movement of the carcass over the dredge frame and may warrant future examination of alternate designs or elimination of this modification.

The 2006 Panama City gear trials showed that moving the cutting bar forward and adding round stock to the dredge frame was successful in creating a ramp that caused turtle carcasses to go over the dredge. Further work will incorporate the same frame design with modifications to the bale to reduce the likelihood of entrapping turtles under these bars.

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Appendix 1. Daily Activity Summaries and Observations

Operations were conducted from June 18-22, 2006 in the Gulf of Mexico, 1/4 mile offshore of Shell Island, Panama City Florida in 20-30 ft. of water. The *F/V Captain Wick*, a 70-ft fish/shrimp trawler, was used as the research platform.

Sunday 6/18/06

- Attached A-frame and necessary stays on vessel
- Loaded dredge on vessel
- Setup of RF camera system on dredge
- Conducted one tow to observe dredge attitude with different scope and speed combinations.

Tow #1 Dredge attitude observations with different scope and speed combinations
Scope: Varied
Cable: Varied
Depth: 28-29 ft
Speed: Varied

Comments: RF camera installed on starboard side of center bar in dredge bale facing aft, providing a view of the starboard side of cutting bar. The amount of cutting bar bottom contact was observed as an indicator of dredge attitude. It was assumed that the more contact the cutting bar made the lower the angle of the bale relative to the bottom.

1.8:1 scope @ 2.1 knots – Occasional bottom contact
1.8:1 scope @ 3.2 knots – Infrequent bottom contact
1.8:1 scope @ 4.0 knots – No bottom contact

2.6:1 scope @ 4.0 knots – Infrequent bottom contact

3.5:1 scope @ 1.5 knots – Constant bottom contact
3.5:1 scope @ 2.0 knots – Frequent bottom contact
3.5:1 scope @ 3.0 knots – Frequent bottom contact

4.3:1 scope @ 3.0 knots – Frequent bottom contact
4.3:1 scope @ 4.0 knots – Frequent bottom contact

5.1:1 scope @ 3.0 knots – Nearly constant bottom contact
5.1:1 scope @ 4.0 knots – Nearly constant bottom contact
5.1:1 scope @ 5.2 knots – Frequent bottom contact

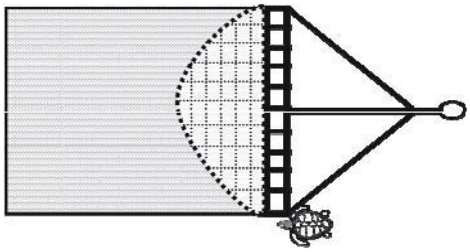
Monday 6/19/06

- Conducted one tow with divers to observe dredge attitude, collect measurements, and handheld video.
- Conducted two tows with turtle carcasses deployed ahead of the dredge.

Tow #2 Dredge attitude observations and video collection with 5.1:1 ratio at 3.0 kts
Scope: 5.1:1
Cable: 150 ft
Depth: 29 ft
Speed: 3.0 kts

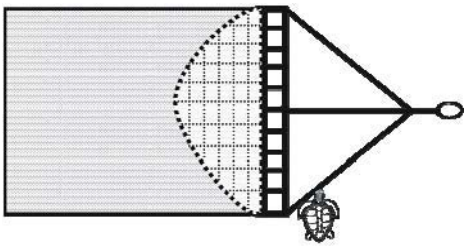
Comments: The cutting bar was making nearly constant contact with the bottom. The bale of the dredge was nearly parallel with the bottom with less than 6-inches of clearance. Lots of sand was being pushed by the cutting bar due to the low angle of attack and the bag was nearly covered with sand at the end of the tow. No more than a few of inches of clearance was observed between the cutting bar and the bottom.

Tow #3 Turtle carcass #1 deployed ahead of the dredge
Scope: 5.1:1
Cable: 150 ft
Depth: 28 ft
Speed: 3.0 kts
Carcass Placement and Orientation:



Comments: The carcass was placed in front of the starboard edge of the dredge and did not go under the bale. The carcass deflected off the starboard shoe away from the dredge. Divers deploying the carcass had trouble locating the oncoming dredge due to the length of cable deployed. Also, the captain had trouble making adjustments due to the amount of cable deployed.

Tow #4 Turtle carcass #1 deployed ahead of the dredge
Scope: 5:1
Cable: 125 ft
Depth: 25 ft
Speed: 3.0 kts
Carcass Placement and Orientation:



Comments: Cable length was shortened to 125 ft to provide the captain with better maneuverability and allowed divers to adjust to dredge more effectively. The carcass was placed in front of the starboard edge of the dredge and did not go under the bale. The carcass was held on the outer edge of the bale for approximately 30 seconds before it came off and went up and over the dredge. The amount of clearance between the bale and the bottom at this scope did not allow the turtle carcass to pass under the bale. Because of difficulties experienced with the 5:1 ratio, it was agreed that subsequent tows should match the 2005 testing scenario with a 3:1 ratio at 3.0 knots. In 2005, scallop dredge fishermen and industry representatives that attended testing determined that this ratio speed combination provided a dredge attitude that best matched that observed on commercial dredges during normal fishing conditions. The 3:1 ratio also provided better maneuverability, diver response time, and enough clearance to place carcasses under the bale, which was a more conservative testing approach.

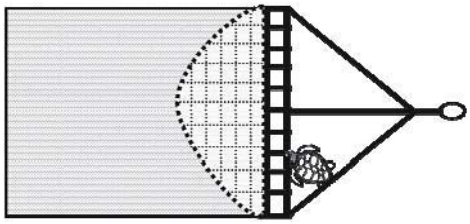
Tuesday 6/20/06

- Conducted four tows with turtle carcasses deployed ahead of the dredge

Tow #5 Turtle carcass #2 deployed ahead of the dredge
Scope: 3:1
Cable: 90 ft
Depth: 30 ft
Speed: 3.0 kts
Carcass Placement and Orientation: Missed

Comments: The apex of the dredge bale was 14-20-inches off the bottom and the cutting bar was making occasional contact with 3-4-inches of clearance observed and very little sand observed going over the cutting bar. No interaction was recorded; the dredge missed the carcass deployment dive team.

Tow #6 Turtle carcass #2 deployed ahead of the dredge
Scope: 3:1
Cable: 90 ft
Depth: 30 ft
Speed: 3.0 kts
Carcass Placement and Orientation:



Comments: The carcass was placed under the starboard side of the dredge bale and made contact with the cutting bar in the center of the starboard side of the dredge approximately 3 feet from the edge (Figure 2A). The carcass was facing the dredge and turned slightly to the right, with the left front flipper trapped under the cutting bar by water pressure and the posterior edge of the shell held down by the bale (Figure 2B). The carcass was held in this position for approximately 4 minutes before divers removed it. The front flipper was trapped under the cutting bar and against a vertical piece of round stock that was added to the front edge of the cutting bar and pressure plate (Figure 2C and D).

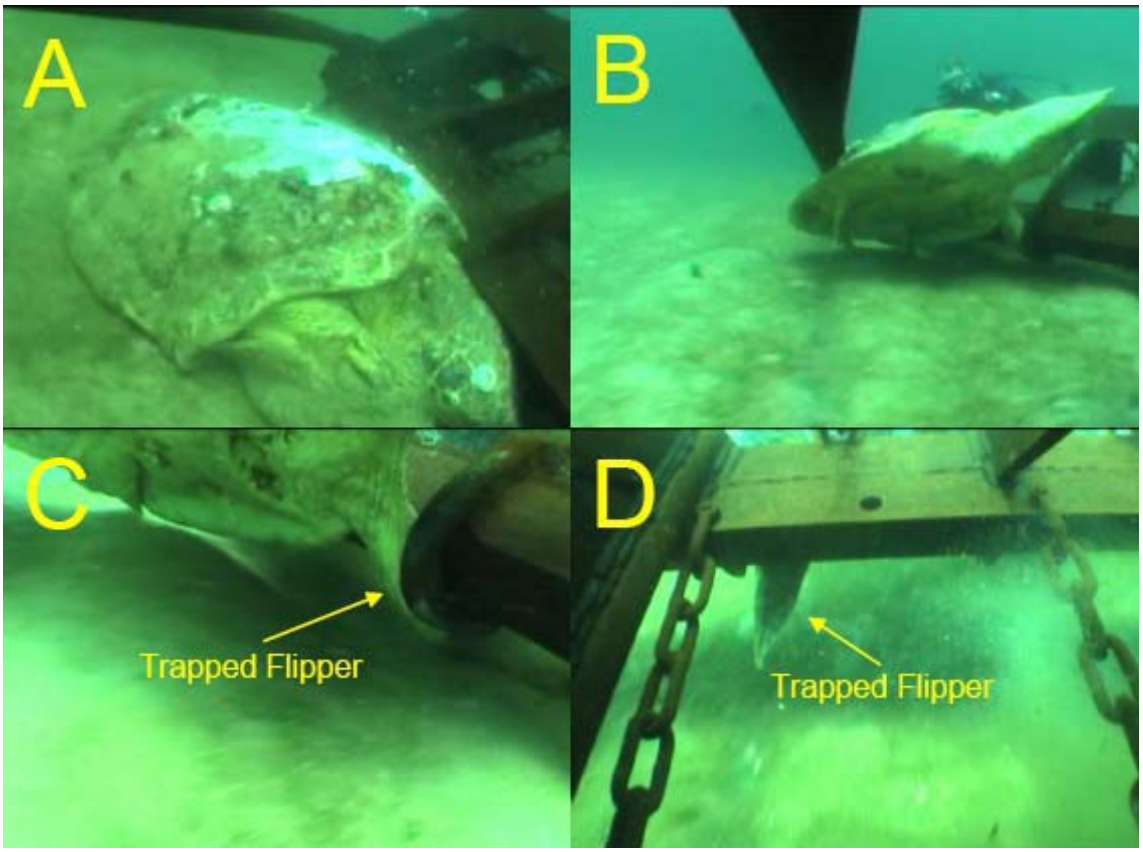
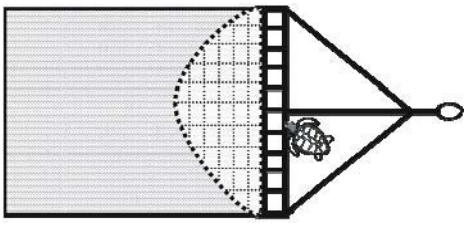


Figure 2. Photos taken from video collected during tow #6 of modified scallop dredge testing June 20, 2006. (A) Initial impact with the dredge; (B) carcass caught under bale; (C) flipper under cutting bar and against round stock modification; (D) rear view of flipper.

Tow #7 Turtle carcass #2 deployed ahead of the dredge
Scope: 3:1
Cable: 90 ft
Depth: 28 ft
Speed: 3.0 kts
Carcass Placement and Orientation:



Comments: The carcass was placed under the starboard side of the dredge bale and made contact with the cutting bar just to the starboard side of the center bar approximately 6 feet from the edge of the frame (Figure 3A). The carcass was facing the dredge and turned slightly to the right with the front left flipper and head making initial contact. The carcass then flipped up onto the front of the dredge (Figure 3B and C). The right front flipper was momentarily trapped under the cutting bar before releasing and allowing the carcass to flip up and over the dredge (Figure 3C and D).

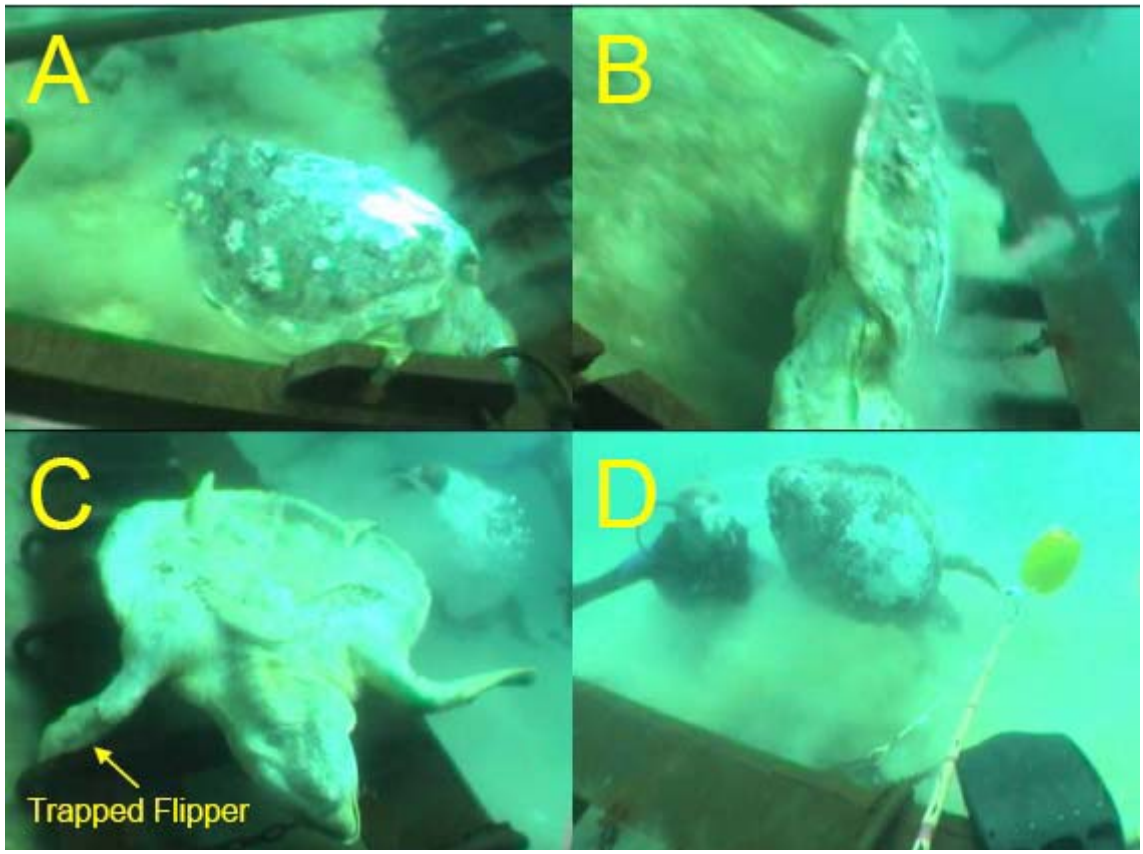
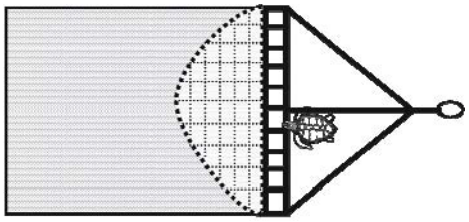


Figure 3. Photos taken from video collected during tow #7 of modified scallop dredge testing June 20, 2006. (A) Initial impact with the dredge; (B) carcass beginning to flip up; (C) carcass flipping onto dredge with flipper momentarily trapped; (D) carcass going over dredge.

Tow #8 Turtle carcass #3 deployed ahead of the dredge
Scope: 3:1
Cable: 90 ft
Depth: 27 ft
Speed: 3.0 kts
Carcass Placement and Orientation:



Comments: The carcass was placed under the starboard side of the dredge bale and made contact with the cutting bar just to the starboard side of the center bar approximately 6 feet from the edge of the frame (Figure 4A). The carcass was facing the dredge and made contact head first. The carcasses stayed in position for a few seconds and proceeded to flip up and over the pressure plate where it was recovered by divers (Figure 4B).

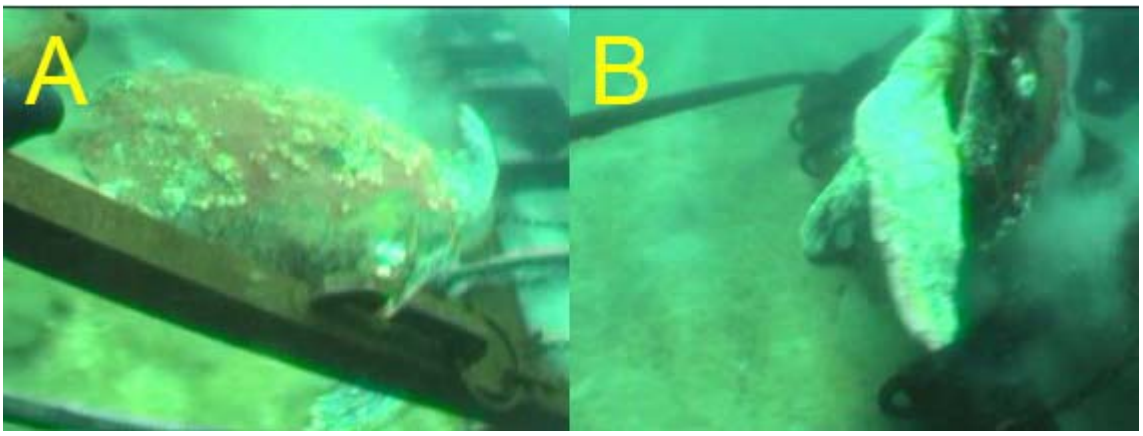


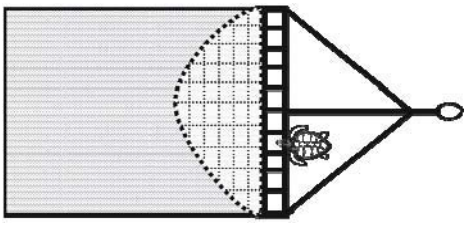
Figure 4. Photos taken from video collected during tow #8 of modified scallop dredge testing June 20, 2006. (A) Initial impact with the dredge; (B) carcass flipping up and over the dredge.

Wednesday 6/21/06

- Conducted five tows with turtle carcasses deployed ahead of the dredge

Tow #9 Turtle carcass #4 deployed ahead of the dredge
Scope: 3:1
Cable: 90 ft
Depth: 31 ft
Speed: 3.0 kts
Carcass Placement and Orientation: Missed

Tow #10 Turtle carcass #4 deployed ahead of the dredge
Scope: 3:1
Cable: 90 ft
Depth: 34 ft
Speed: 3.0 kts
Carcass Placement and Orientation:



Comments: The carcass was placed under the starboard side of the dredge bale and made contact with the cutting bar near the middle of the starboard side of the dredge approximately 4 feet from the edge of the frame (Figure 5A). The carcass was facing the dredge and made contact head first. The carcass slid up the face of the dredge immediately after impact and proceeded to go over the pressure plate (Figure 5B).

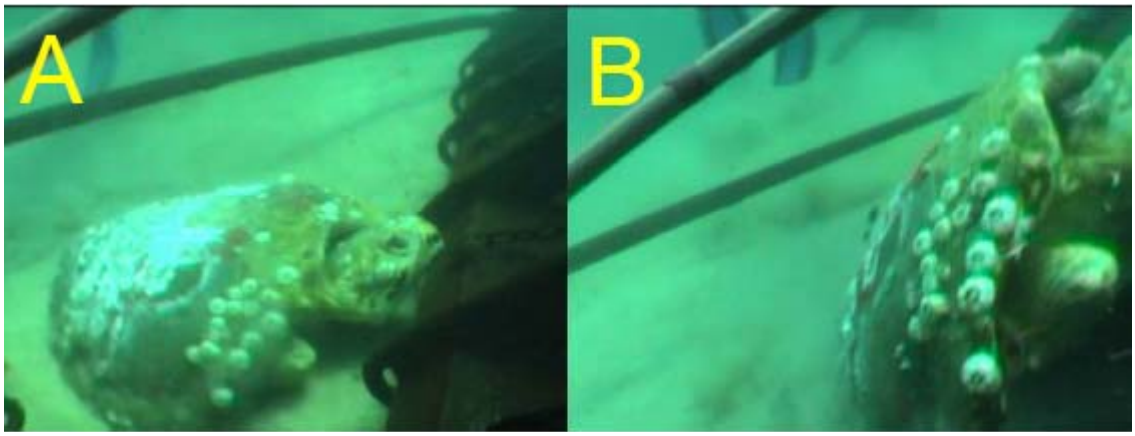
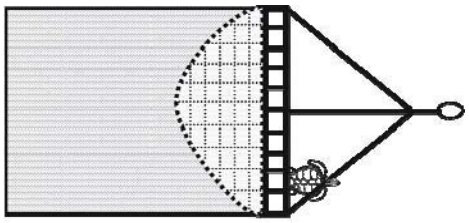


Figure 5. Photos taken from video collected during tow #10 of modified scallop dredge testing June 21, 2006. (A) Initial impact with the dredge; (B) carcass sliding up and over the dredge.

Tow #11 Turtle carcass #3 deployed ahead of the dredge
Scope: 3:1
Cable: 90 ft
Depth: 30 ft
Speed: 3.0 kts
Carcass Placement and Orientation:



Comments: The carcass was placed under the starboard side of the dredge bale and made contact with the cutting bar near the edge of the starboard side of the dredge approximately 3 feet from the edge of the frame (Figure 6A). The carcass encountered the dredge tail first. The posterior edge of the carapace was caught under the cutting bar while the anterior portion of the carapace was held down by the dredge bale, which prevented the carcass from flipping up and over the dredge frame (Figure 6B).

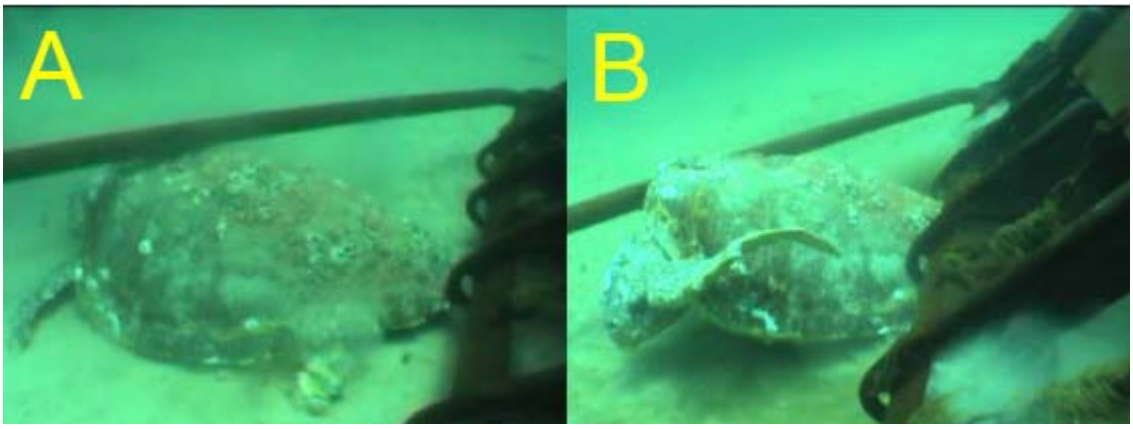
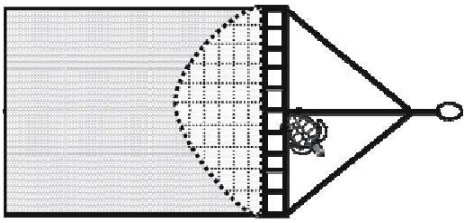


Figure 6. Photos taken from video collected during tow #11 of modified scallop dredge testing June 21, 2006. (A) Initial impact with the dredge; (B) carcass caught under bale and cutting bar.

Tow #12 Turtle carcass #4 deployed ahead of the dredge
Scope: 3:1
Cable: 90 ft
Depth: 29 ft
Speed: 3.0 kts
Carcass Placement and Orientation:



Comments: The carcass was placed under the starboard side of the dredge bale and made contact with the cutting bar near the center of the dredge just on the starboard side of the center brace bar approximately 6 feet from the edge of the frame (Figure 7A). The carcass encountered the dredge tail first and was angled to the right. Upon impact the carcass slid up the face of the dredge and stalled on the pressure plate (Figure 7B and C). The carcass's front left flipper was trapped under the cutting bar and against a vertical piece of round stock (Figure 7D). The carcass was held in this position for approximately one minute before it moved the rest of the way over the dredge.

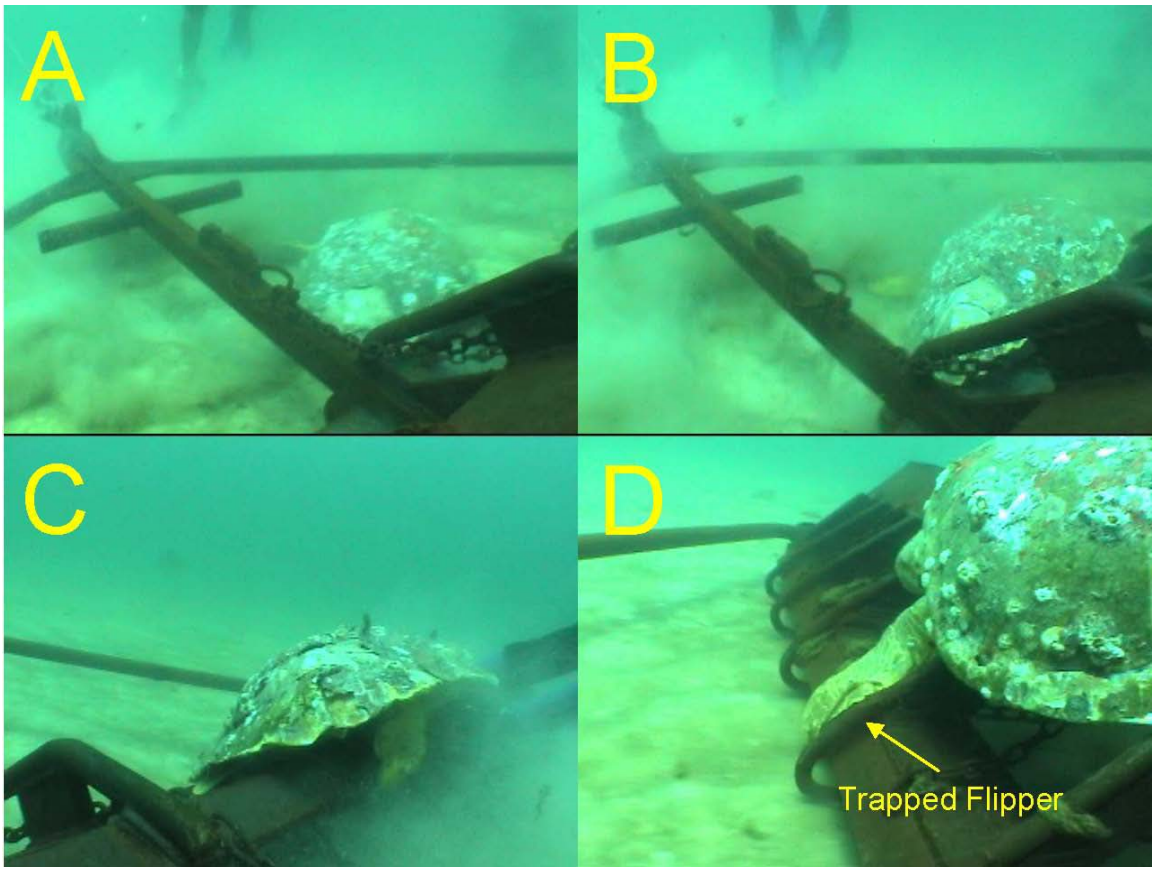
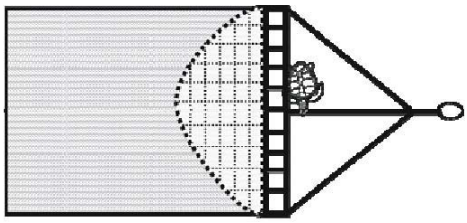


Figure 7. Photos taken from video collected during tow #12 of modified scallop dredge testing June 21, 2006. (A) Initial impact with the dredge; (B) carcass sliding up face of the dredge; (C) carcass stopping on the pressure plate; (D) flipper which may have temporarily held carcass in place.

Tow #13 Turtle carcass #4 deployed ahead of the dredge
Scope: 3:1
Cable: 90 ft
Depth: 30 ft
Speed: 3.0 kts
Carcass Placement and Orientation:



Comments: The carcass was placed under the port side of the dredge bale and made contact with the cutting bar near the center of the dredge just on the port side of the center brace bar approximately 5 feet from the edge of the frame (Figure 8A). The carcass was facing to the right and encountered the dredge along its entire right side. Upon impact the carcass flipped up and over the dredge (Figure 8B).

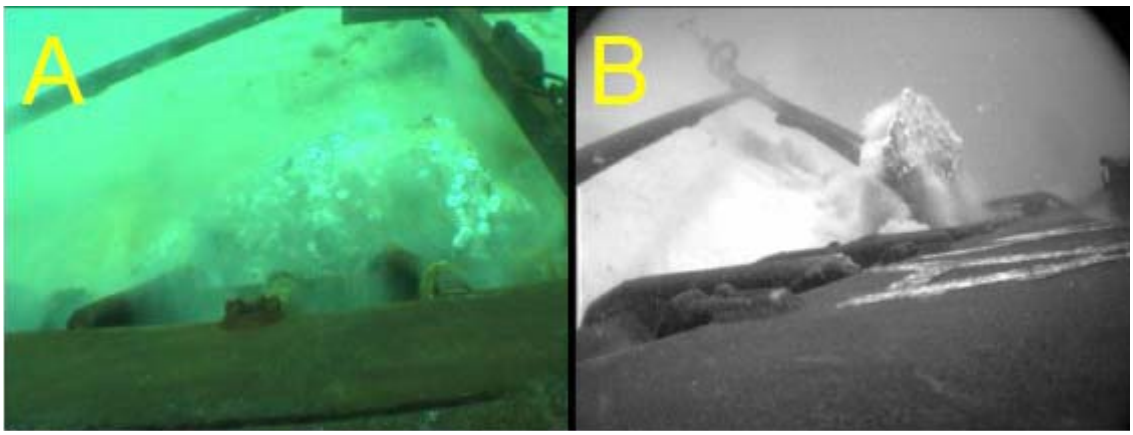
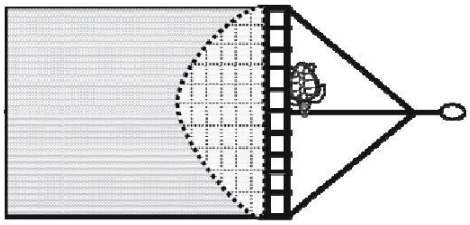


Figure 8. Photos taken from video collected during tow #13 of modified scallop dredge testing June 21, 2006. (A) Initial impact with the dredge; (B) carcass flipping up and over the dredge.

Thursday 6/22/06

- Conducted four tows with turtle carcasses deployed ahead of the dredge
- Unloaded modified dredge
- Completed rigging change for trawl work

Tow #14 Turtle carcass #5 deployed ahead of the dredge
Scope: 3:1
Cable: 90 ft
Depth: 30 ft
Speed: 3.0 kts
Carcass Placement and Orientation:



Comments: The carcass was large and bloated and required the addition of thirty pounds of weight to sink. The carcass was placed under the port side of the dredge bale and made contact with the cutting bar just to the port side of the center brace bar approximately 5 feet from the edge of the frame (Figure 9A). The carcass was facing to the right and encountered the dredge along its entire right side. Upon impact the carcass slid up the face of the dredge and stopped (Figure 9B). The attached weights may have hung on the face of the dredge preventing it from sliding completely over the dredge. In addition, both front flippers were under the cutting bar which may have also prevented the carcass from sliding any further up the face of the dredge (Figure 9B).

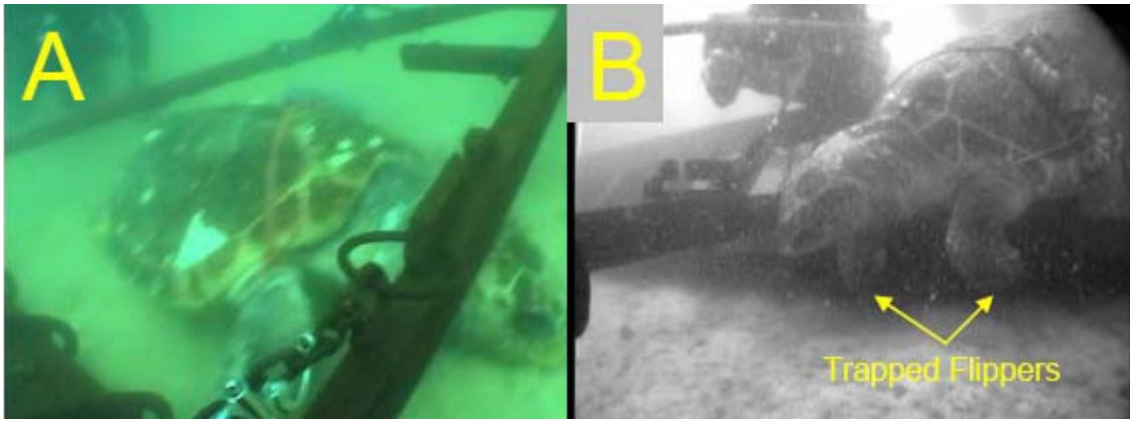
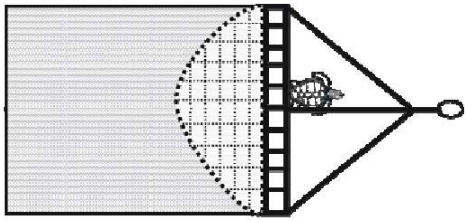


Figure 9. Photos taken from video collected during tow #14 of modified scallop dredge testing June 22, 2006. (A) Initial impact with the dredge; (B) carcass sliding up the face of the dredge.

Tow #15 Turtle carcass #5 deployed ahead of the dredge
Scope: 3:1
Cable: 90 ft
Depth: 32 ft
Speed: 3.0 kts
Carcass Placement and Orientation:



Comments: This was the same carcass used on the previous tow and required the addition of weights to sink. The carcass was placed under the port side of the dredge bale and made contact with the cutting bar on the port side of the center brace bar about 5 feet from the edge of the frame (Figure 10A). The carcass encountered the dredge tail first. Upon impact the carcass flipped up and over the face of the dredge (Figure 10B).

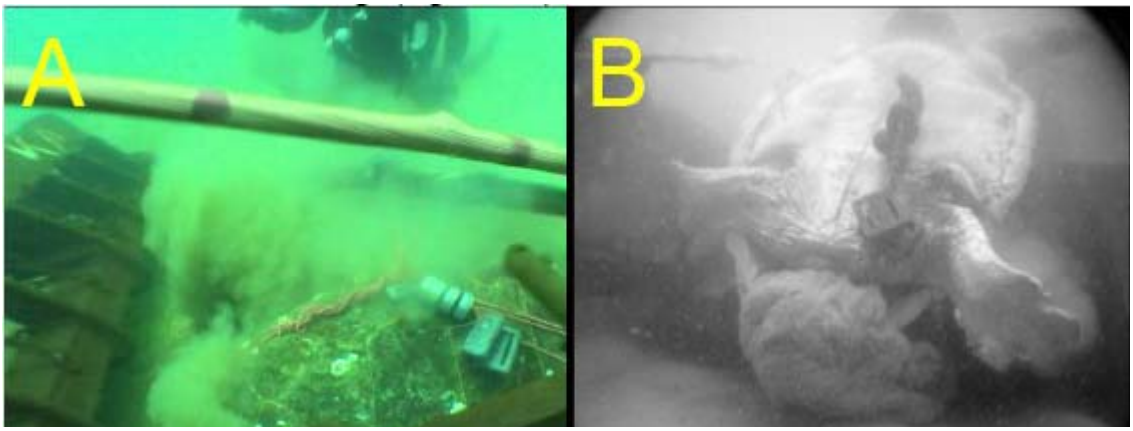
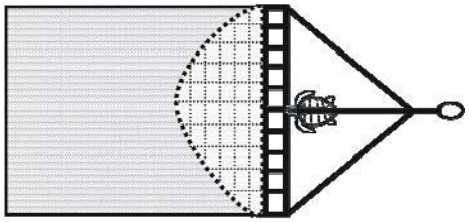


Figure 10. Photos taken from video collected during tow #15 of modified scallop dredge testing June 22, 2006. (A) Initial impact with the dredge; (B) carcass flipping up and over the dredge.

Tow #16 Turtle carcass #2 deployed ahead of the dredge
Scope: 3:1
Cable: 90 ft
Depth: 31 ft
Speed: 3.0 kts
Carcass Placement and Orientation:



Comments: The carcass was placed directly under the center brace bar (Figure 11A). The carcass encountered the dredge head first and was held under the center brace bar until divers removed it (Figure 11B).

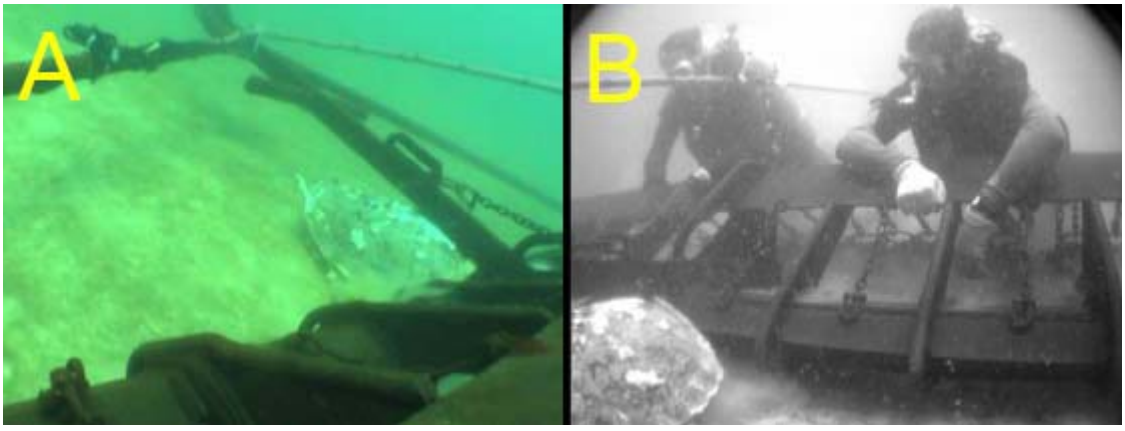
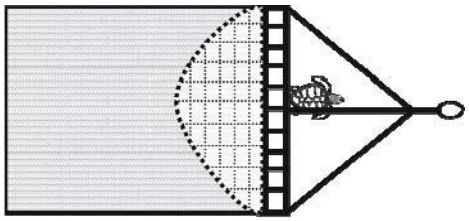


Figure 11. Photos taken from video collected during tow #16 of modified scallop dredge testing June 22, 2006. (A) Initial impact with the dredge; (B) divers preparing to remove carcass from under the center brace bar.

Tow #17 Fiberglass Turtle Model #1 deployed ahead of the dredge
Scope: 3:1
Cable: 90 ft
Depth: 30 ft
Speed: 3.0 kts
Plastic Turtle Placement and Orientation:



Comments: The model was placed under the port side of the dredge bale and made contact with the cutting bar near the center of the dredge just on the port side of the center brace bar 5 feet from the edge of the frame (Figure 12A and B). The model encountered the dredge tail first. Upon impact the model started to flip up but the head caught under a cross bar where wheels had been previously mounted on the center bar. This prevented the model from flipping up and over the dredge (Figure 12C). In addition, the right rear flipper was trapped under the cutting bar (Figure 12D).

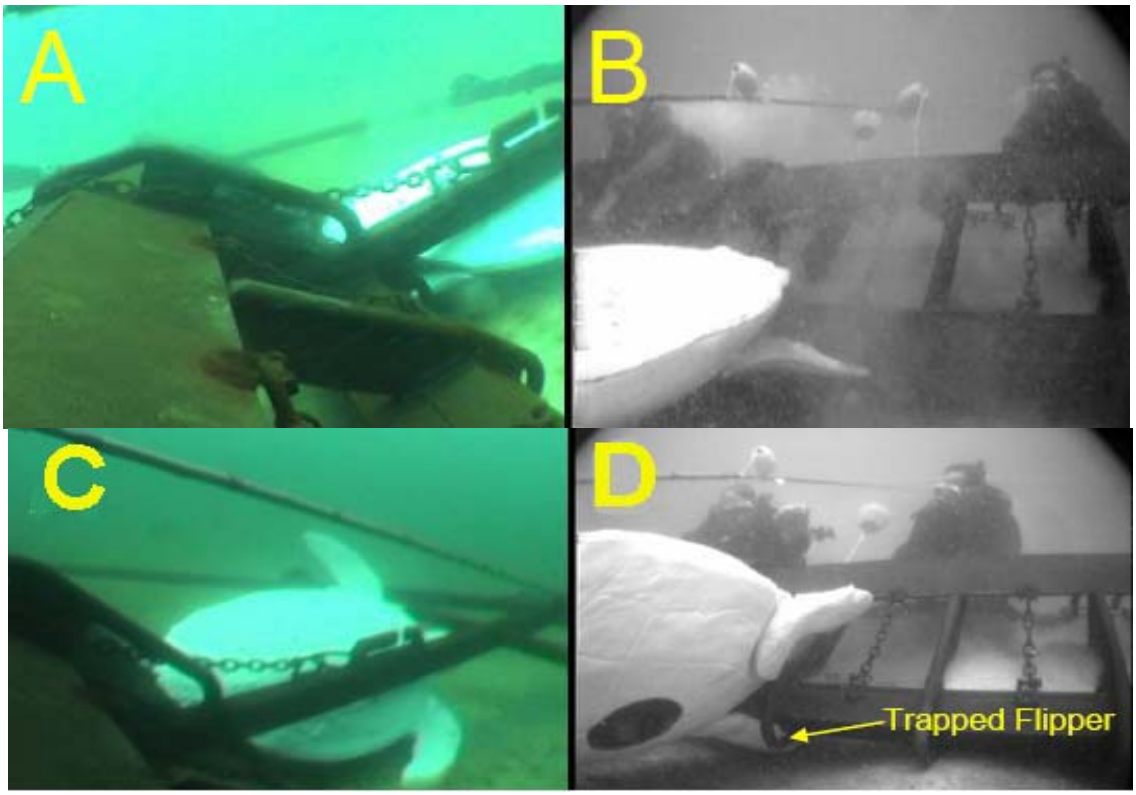


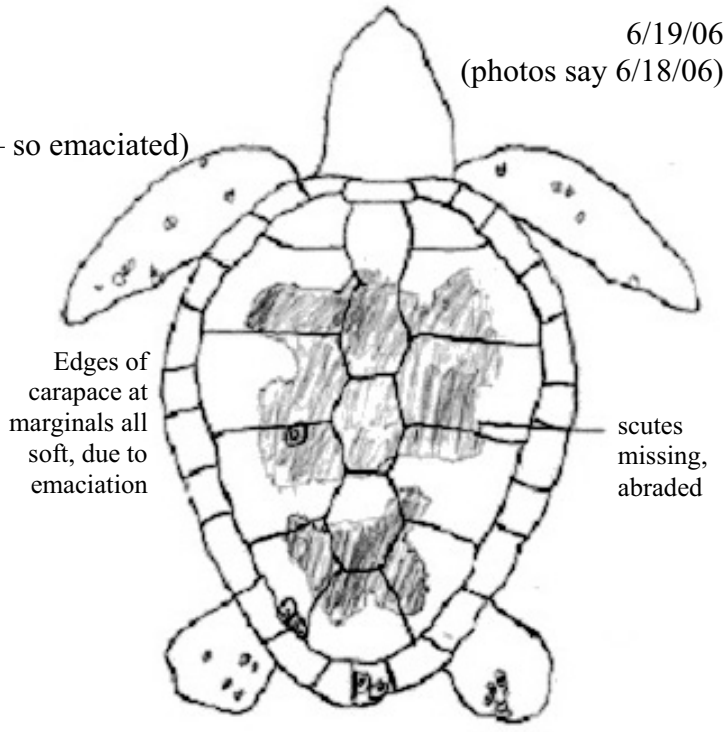
Figure 12. Photos taken from video collected during tow #17 of modified scallop dredge testing June 22, 2006. (A) Initial impact with the dredge; (B) initial impact with the dredge; (C) turtle model caught with head under crossbar (D) rear flipper of model shown under cutting bar.

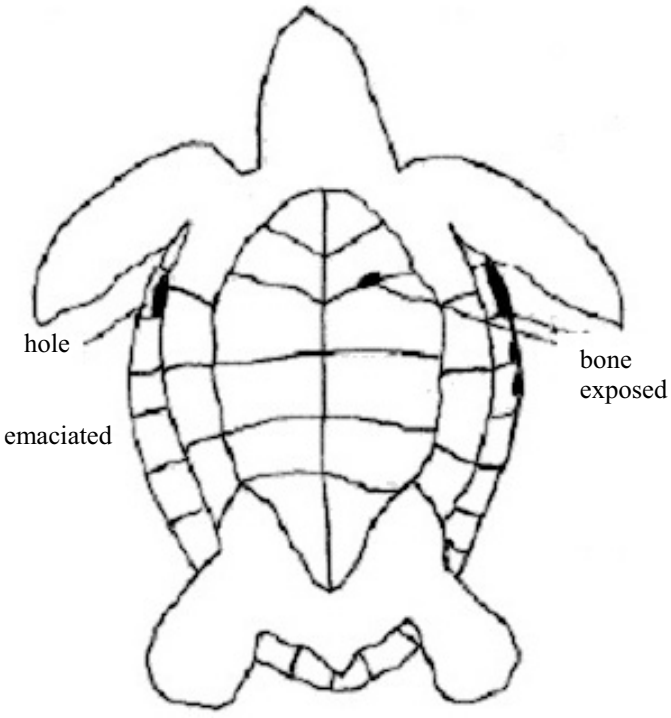
Appendix 2. Pre- and post-test documentation

Turtle #1 – Pre-test documentation 6/19/06
MXH20060301-01 (photos say 6/18/06)

BD = 17.3 cm (carapace depth – so emaciated)
PL = 49.0 cm
HW = 12.9 cm
CLSL = 68.6 cm
NNCLSL = 67.7 cm
CWSL = 57.1 cm
CLOC = 72.6 cm
NNCLOC = 72.0 cm
CWOC = 68.0 cm
Wt = 60 lb – dry and in water

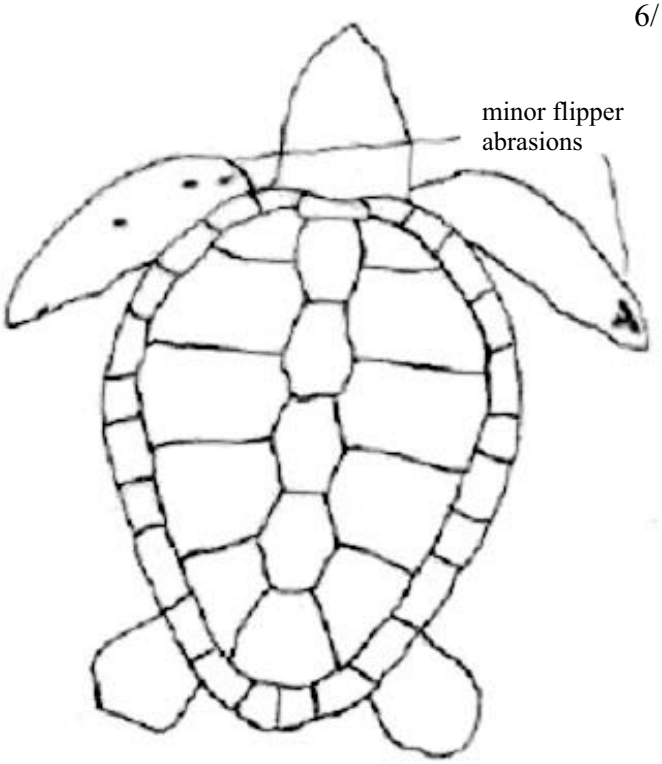
Tagged SSR891 for ID purposes – RRF
" SSR893 " " " – LRF





Turtle #1 – Post-test documentation 6/19/06

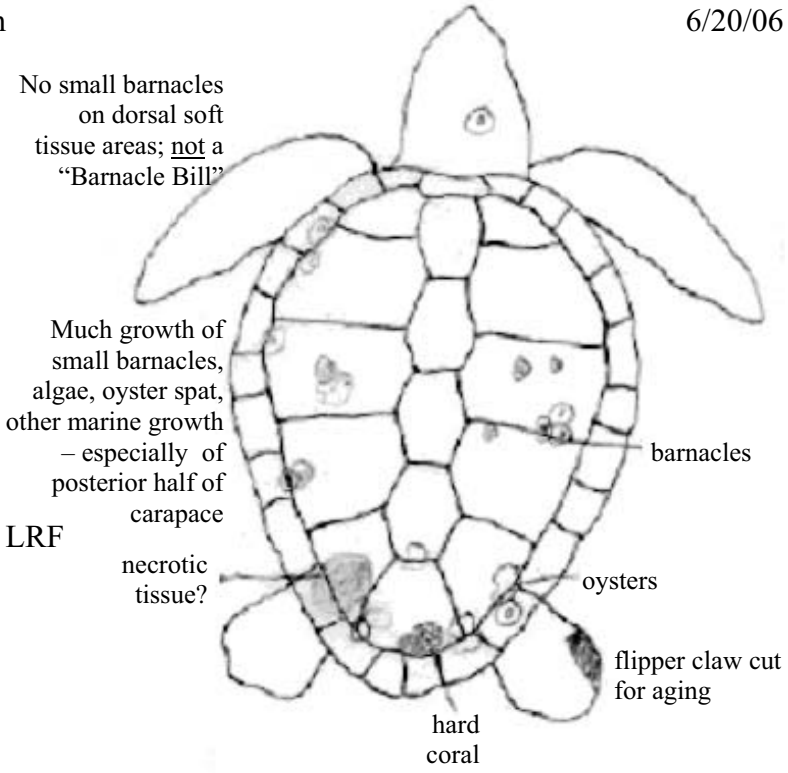
Tow #3
Turtle went around end of dredge, minimal impact. Carcass examined, no visible injuries, minor abrasions on front flippers.

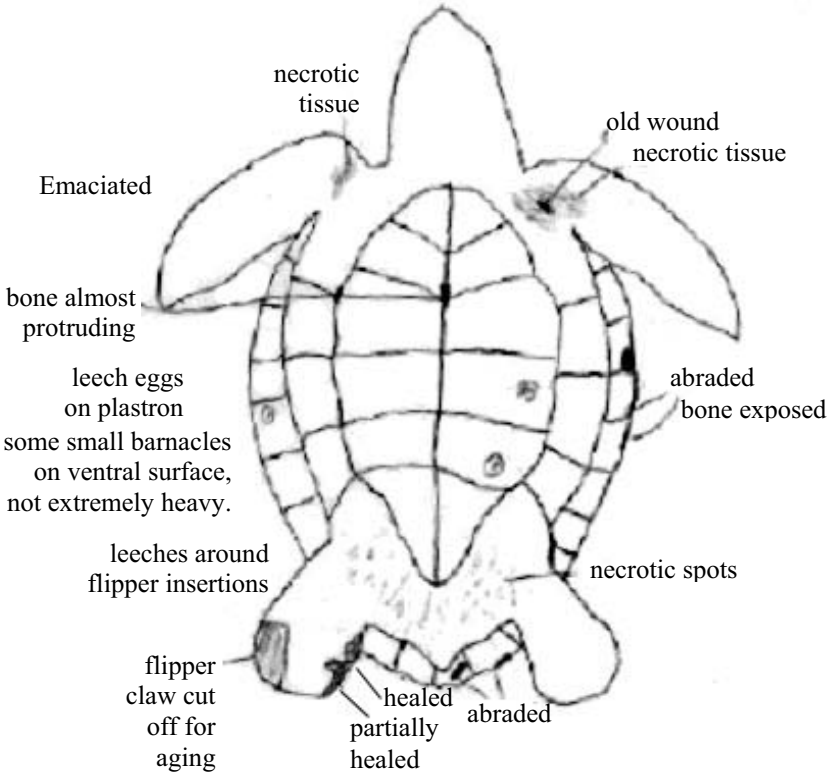


Turtle #2 – Pre-test documentation 6/20/06
BEL20060501-01

BD = 21.3 cm
PL = 49.1 cm
HW = 13.1 cm
CLSL = 65.5 cm
NNCLSL = 64.6 cm
CWSL = 55.5 cm
CLOC = 71.1 cm
NNCLOC = 70.2 cm
CWOC = 70.4 cm
Wt = 68 lb – dry and in water

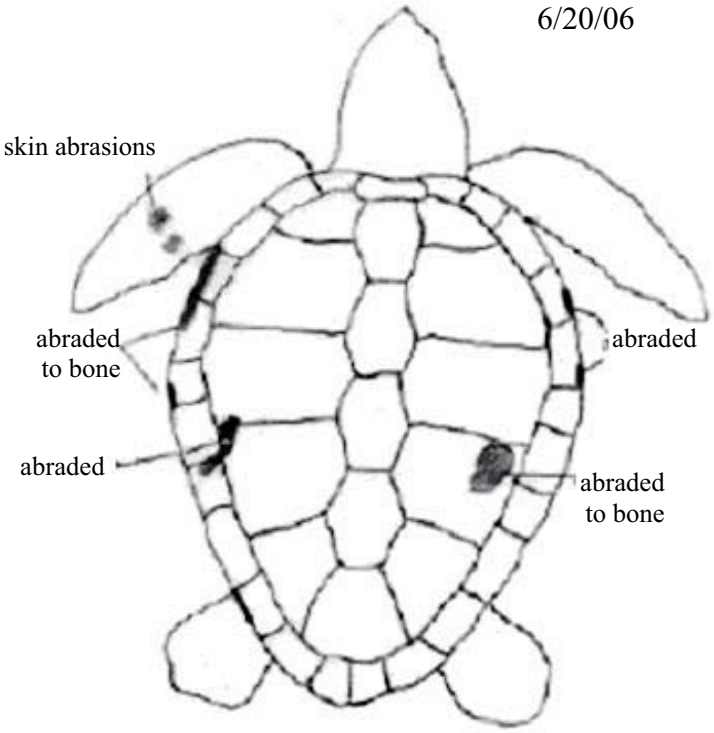
Tagged SSR895 for ID purposes on LRF





Turtle #2 Post-test documentation 6/20/06

Tow #6 (see diagrams):
Abrasions on L & R side marginals, both dorsal and ventral. Crack in bone in left side marginals, only visible ventral. Abraded to bone on RC #4.

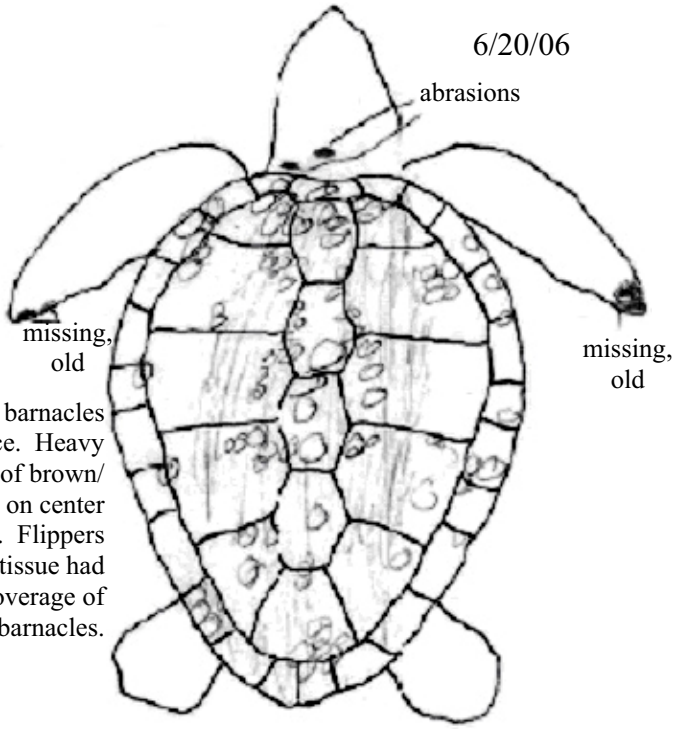


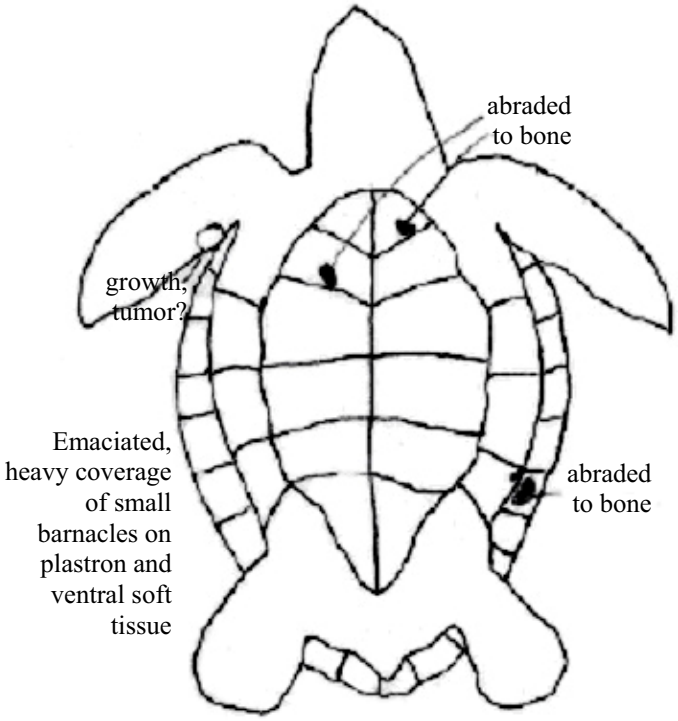
Turtle #3 Pre-test documentation 6/20/06

LAB20060525-01 25°44.783
80°08.563

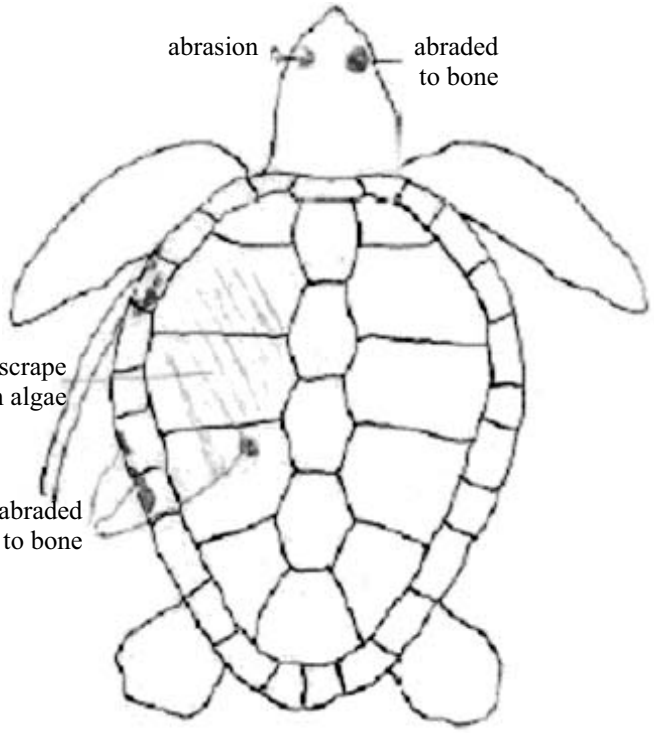
BD = 26.6 cm
PL = 58.2 cm
HW = 16.0 cm
CLSL = 80.1 cm
NNCLSL = 78.8 cm
CWSL = 61.6 cm
CLOC = 87.6 cm
NNCLOC = 86.3 cm } over barnacles
CWOC = 80.3 cm
Wt = 110 lb dry weight;
not weighed in water

Tagged SSR896 for ID purposes on LRF

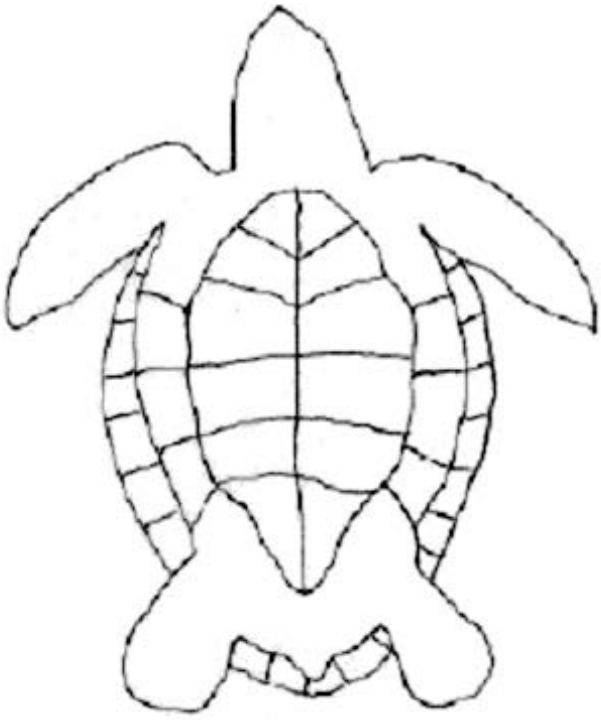




Turtle #3 Post-test documentation 6/20/06
Tow #8



Some barnacles (~5-10%) knocked off center carapace



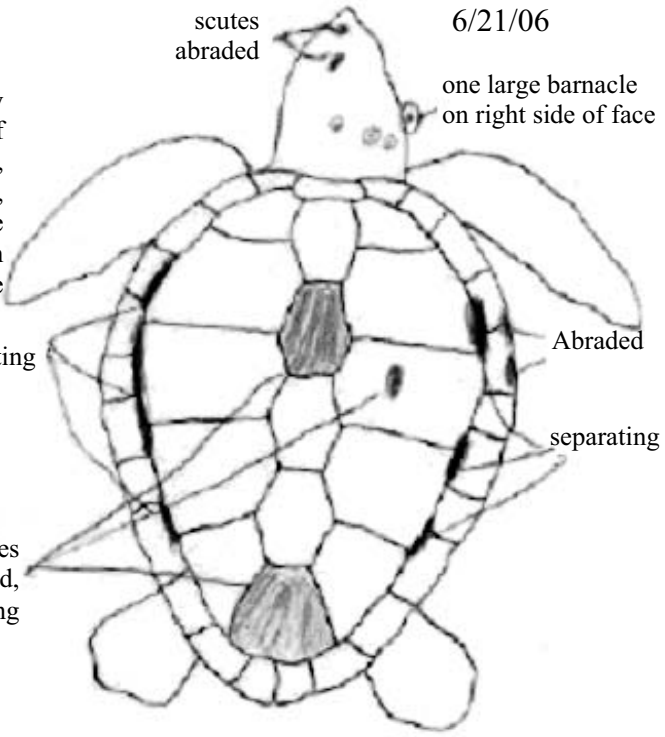
No additional ventral injuries seen

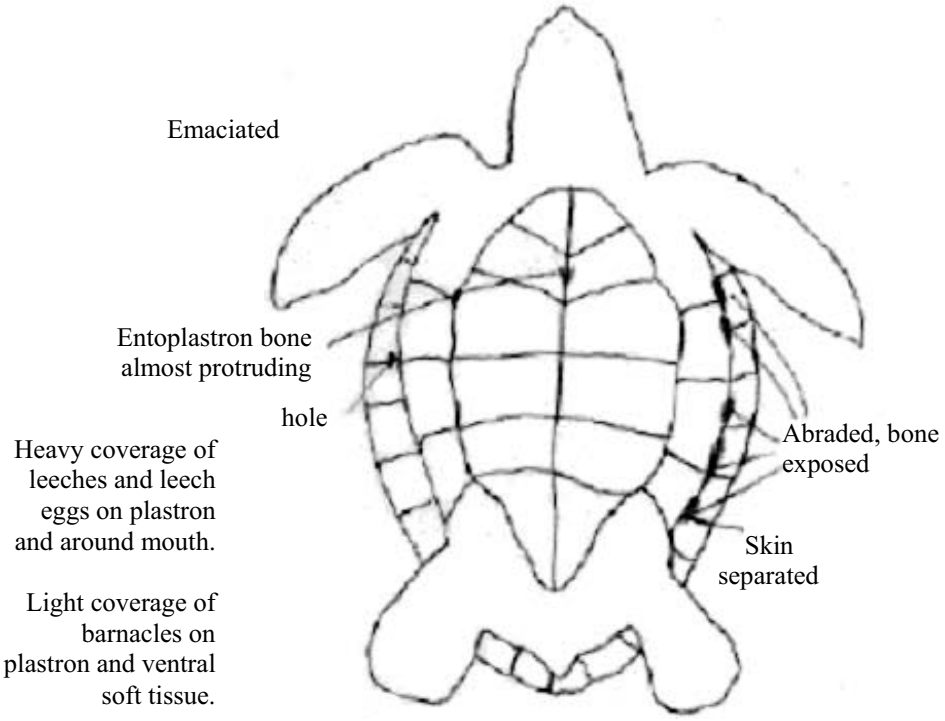
Turtle #4 Pre-test documentation 6/21/06

BEL20051215-01

BD = 17.6 cm
PL = 49.4 cm
HW = 14.6 cm
CLSL = 71.1 cm
NNCLSL = 70.2 cm
CWSL = 59.6 cm
CLOC = 76.6 cm
NNCLOC = 75.6 cm } over
CWOC = 72.7 cm } barnacles
Wt = 70 lb

Tagged SSR897 for ID purposes on LRF



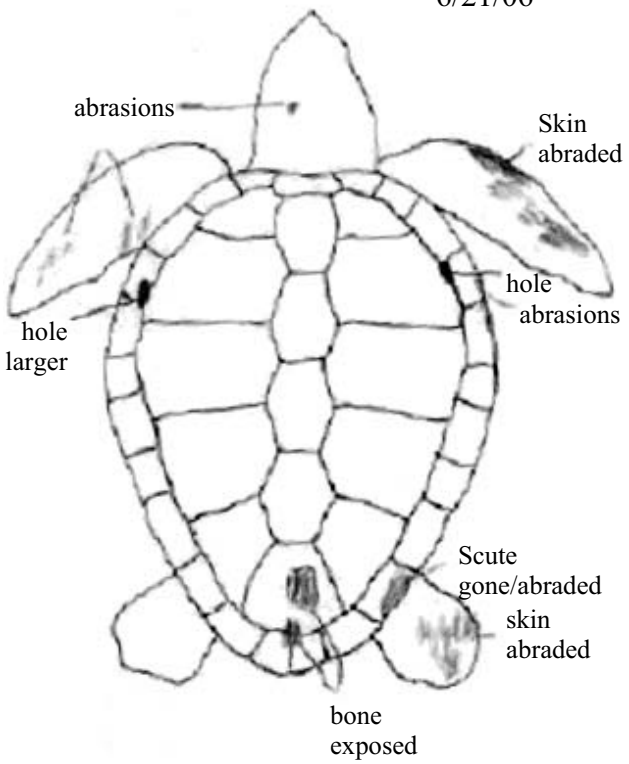


Turtle #4 Post-test documentation 6/21/06

Tow #10

Scutes abraded from dorsal surfaces of both front flippers and R rear flipper.

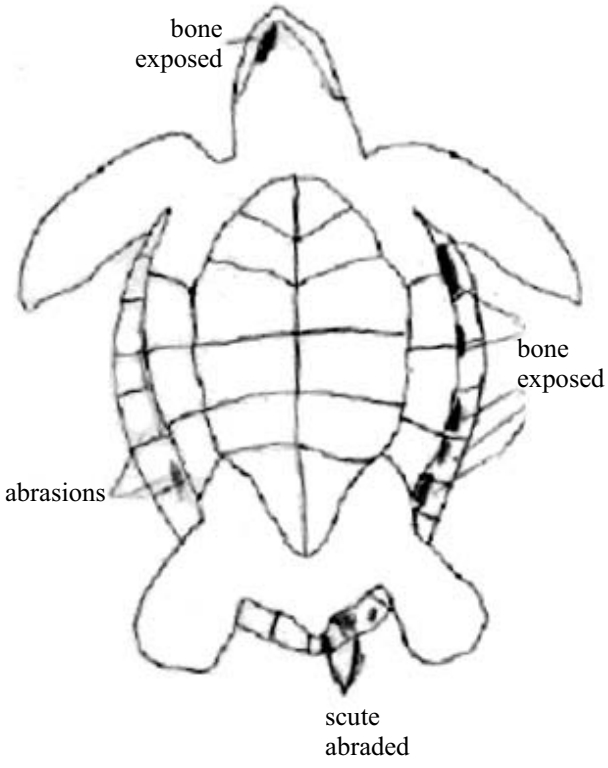
Separation/hole larger between L marginals and LC #2. Hole between R marginals. RC #2 scute gone/abraded on R posterior marginal and minor on R side marginals. Bone exposed (skin abraded) on posterior carapace where scute was missing previously.



Bone exposed on right side of jaw bone.

Bone exposed along left side of plastron where marginals meet plastron – more abraded and over larger area than pre-test documentation.

Scutes abraded on ventral posterior marginals.

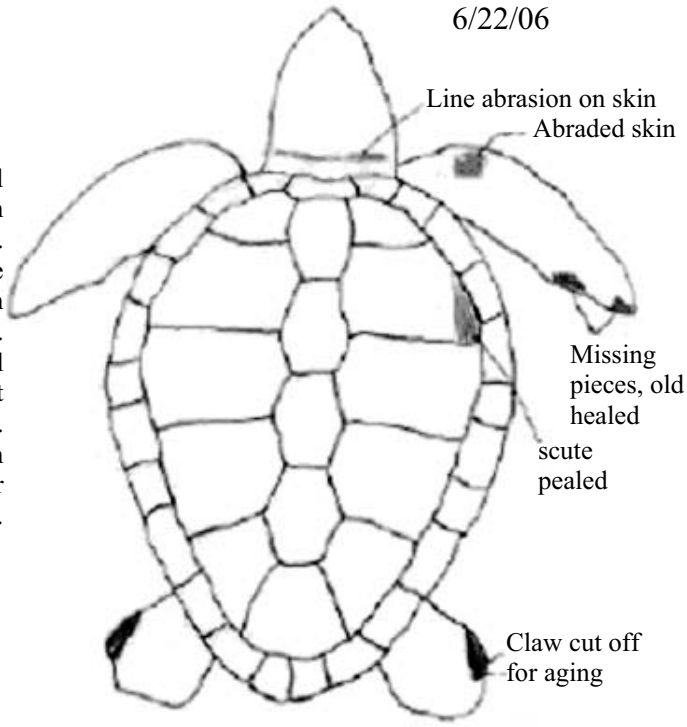


Tow #12 – no additional damage
Tow #13 – carapace bone broken. RC#3 and adjacent marginals; crack in posterior carapace.

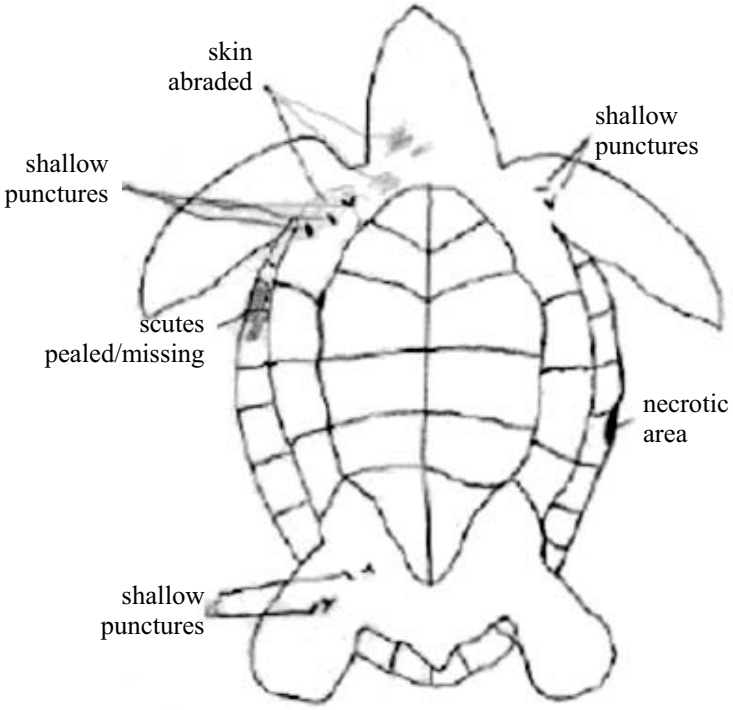
Turtle #5 Post-test documentation 6/22/06
MAN20060408-01

BD	=	30.0 cm
PL	=	64.1 cm
HW	=	17.6 cm
CLSL	=	85.1 cm
NNCLSL	=	82.5 cm
CWSL	=	64.0 cm
CLOC	=	91.0 cm
NNCLOC	=	89.1 cm
CWOC	=	83.3 cm
Wt	=	160 lb dry

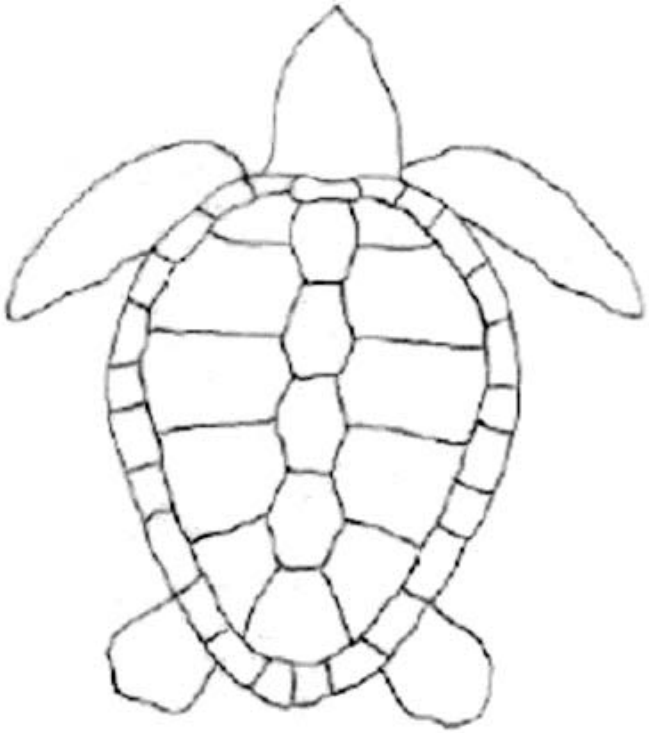
Few small barnacles on flippers. Several large barnacles on carapace. Some small barnacles on left side of carapace. Green algae on posterior carapace.



Tagged SSR898 for ID purposes on LRF



Turtle #5 Post-test documentation 6/22/06



Tow #14

Carcass examined from a small boat while carcass still in water.

No additional damage seen relative to pre-test documentation.

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