Evaluation of USCG Cutter Point Francis Propeller Strike on Right Whale Calf

Field Number: RKB-1424

By

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March 9, 2005

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Evaluation Results

Propeller Cut Series I

- Created by the USCG Cutter Point Francis (WPB 82356)
- Propeller Diameter – 114.6 cm (45 inches)
- Propeller Blades – 5
- Propeller Rotation – Clockwise (CW)
- Vessel Advance Coefficient – 0.65
- Propeller Pitch - > 29 inches
- Vessel's Approach – from directly ahead of whale
- First Propeller Strike – Cut #18
- Initial Speed of Whale – 4.8 knots
- Maximum Speed of Whale – 6.6 knots (Cut #11)
- Final Speed of Whale – 0 knots

Propeller Cut Series II

- Not Created by the Point Francis
- Propeller Diameter – > 139.5 cm (> 55 inches)
- Propeller Rotation – Counter Clockwise (CCW)
- Vessel's Approach – from left rear with whale ventral surface up

Known Details from Witnessed Event

Vessel

- USCG Cutter Point Francis (WPB 82356)
- Length – 82 feet
- Weight – 67 gross tons
- Twin Screws
- Propeller Diameter - 3.5 feet (42 inches)
- Propeller Blades – 5
- Propeller Pitch – unknown

Right Whale Calf

- Length – 581 cm (19 feet)
- Approximate Weight – 4500 lbs
- Adult right whale was also present

Reported Accident

- Date and Time – 5 Jan 1993 @1517 hrs
- Strike Location - 30° 02.44' N, 81° 16.04' W
- Water Depth – approx. 6.5 fathoms (39 feet)
- Recovery Location - 30° 32.7' N, 81° 11.5' W
- Course of Vessel - 170°
- Average Speed of Vessel 14.2 knots
- Rotation Speed of Propeller – 600 srpm (Turns for 15 knots)
- Advance Coefficient @ 14.2 knots and 600 srpm – 0.68

Summary

According to the Ship's Log, on 5 January 1993 the USCG Cutter Point Francis was traveling south along the east coast of Florida in route to New Orleans, Louisiana for yard availability. At 1517 hrs the Point Francis struck a submerged right whale calf. Visibility was 2 nautical miles, winds were calm, waves were calm, sea swell was 3 feet from 140°, and a check of navigational charts of the area where the accident occurred indicates that the water depth was about 6.5 fathoms (39 feet). The average vessel speed at the time of the accident was 14.2 knots with the propellers making turns for 15 knots at 600 srpm.

The initial accident involving the Point Francis occurred at 30° 02.44' N, 81° 16.04' W, and the crew lost sight of the calf within an hour after the strike. The carcass was once again located four days later on 9 January and recovered at 30° 32.7' N, 81° 11.5' W. The carcass was towed to Jacksonville Harbor, and the necropsy crew arrived early on 10 January. Two distinct series of propeller cuts were identified on the carcass.

In his 15 January report to the Commandant, U. S. Coast Guard, the Commanding Officer, Lt. Burke, reported that at the time of the accident all hands on the bridge were looking forward but did not see any sign of the whale. He reports that without warning the vessel experienced a moderate shutter. He also states in the same report that only one impact was felt. In a 20 January interview, Lt. Burke reported that on the bridge they heard a thump. The Necropsy Report RKB-1424 states that the crew reported hearing two distinct bumping sounds. If the crew members that reported hearing two distinct sounds were below decks, it is possible that they could hear sounds not detected on the bridge, but the detection of two distinct sounds does not necessarily indicate that both propellers of the Point Francis struck the animal.

Based on this evaluation of the propeller cuts, the whale and the Point Francis approached each other head-on (Figure-9), and only one propeller of the Point Francis struck the whale. This strike created propeller cut Series I (Figure-2). It appears that the whale was submerged as it approached the vessel. The full length of the vessel's hull probably passed directly over the whale before it was struck by the propeller. The whale's speed (Figure-1) at the beginning of the strike was about 4.8 knots. This does not indicate any flight response from the whale. The whale's speed increases to 6.8 knots

at Cut #11. This may well be the result of a reflex reaction of the whale resulting from the initial propeller strikes. After Cut #11, the whale apparently becomes incapacitated and its speed drops to 0 knots at Cut #3. According to the necropsy report, the cuts created by the Point Francis were very probably the cause of death, and this evaluation supports that conclusion.

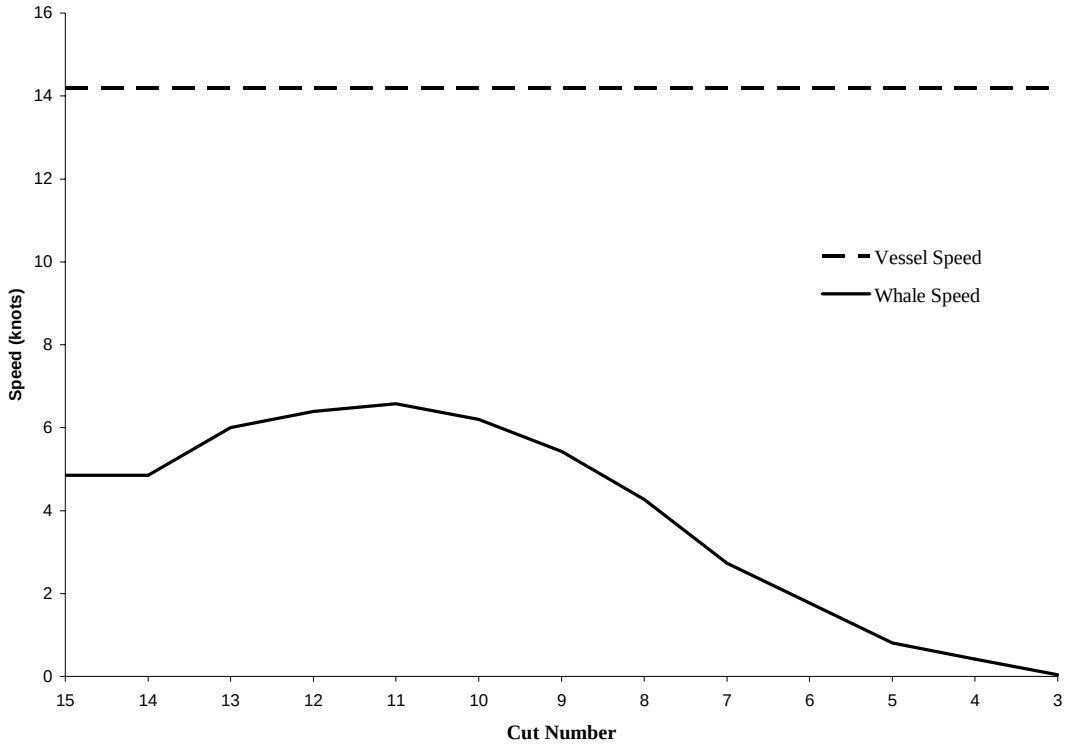

Figure-1: Plot of whale's speed at each cut in Propeller Cut Series I

The second series of propeller cuts, Series II (Figure-2), was not created by the Point Francis. The propeller that created this series of cuts was significantly larger than the propellers of the Point Francis, and this vessel traversed the carcass from tail to head (Figure-10). These cuts were very probably created postmortem while the carcass was floating ventral side up.

Discussion

Necropsy Report RKB-1424 describes the carcass of a right whale calf which was struck by the USCG Cutter Point Francis (WPB 82356) on 5 January 1993. The details of this incident included in the Ship's Logs and statements from the Commanding Officer were available for this evaluation. Also, this evaluation takes advantage of methods and computational tools developed by the author specifically for the purpose of analyzing

photographs of propeller cuts. These improved methods were not available when the necropsy report was prepared, and the methods that were available at that time were based on direct measurements of cut dimensions and shapes of cuts which are generally unreliable and often lead researchers to draw incorrect conclusions.

Based on the information derived using the methods available at the time, the necropsy report notes that "*During impact the crew reported hearing two distinct bumping sounds. The Point Francis has twin propellers.*" The report also notes, "*Two distinct and separate propeller laceration series were evident on the body. …Both series were severe and characteristic of a twin prop vessel. Evidence from the entry and exit sites of each individual slash indicate that the animal was struck from behind as the blades traveled up the body towards the head. The exact speed of the vessel and course prior to impact is not known but should be determined.*" The summary of the necropsy report also notes, "*It is evident that this animal was indeed struck and subsequently killed by the impact suffered from a collision with a large vessel with twin propellers.*"

It is evident from these statements that the necropsy report concludes that both propeller laceration series were created by the Point Francis during the reported incident. Unfortunately, the methods of propeller cut analysis available at the time lead researchers to a conclusion which is not correct. Series I was created by the Point Francis and was correctly identified as the most probable cause of death. Series II was created by a propeller significantly larger than those found on the Point Francis and was probably created postmortem. Also, Series I was created by the Point Francis traversing the animal's body from head to tail, which is opposite the direction reported in the necropsy report. Series II was probably created by a vessel traversing the body from tail to head.

The drawings of the propeller cuts included in the necropsy report (Figure-2) provide a reasonable approximation of the position and character of the propeller cuts visible in photographs of the carcass. The drawing of propeller cut Series I depicts a set of some 18 evenly spaced cuts along the dorsal surface of the animal. The drawing of propeller cut Series II depicts a set of some 9 more or less evenly spaced cuts along the left side of the carcass and across the ventral surface. The separations between successive cuts in Series II are significantly larger than the separations between successive cuts in Series I. Also, individual cuts in Series II are generally longer than the cuts in Series I. These observations can be confirmed by referring to the Table of Measurements from the Necropsy Report (Figure-3). The two series of cuts have distinctly different visual characteristics.

In the hours preceding the accident, the Ship's Log does not include any notations indicating abnormalities in the ship's operation. Therefore, it can be assumed that both engines were online and that the propeller shafts were operating in parallel. Two propellers operating in parallel on the same vessel will normally produce two series of cuts with essentially the same appearance and character. It is readily evident that the two series of cuts identified in this necropsy report were not created under these conditions. Also, the two propellers on the Point Francis could only produce simultaneous cuts on the dorsal and ventral surfaces of the animal if the animal passed directly between the two

propellers while swimming on its side. The 82 foot Point Class Cutters have a keelson just forward of the propellers that would make such a maneuver very difficult if not impossible. These points alone should bring the conclusion that both series of cuts were created by the Point Francis into question. The results of the methods of propeller cut analysis developed by this author make it very apparent that the two series of cuts were created by different vessels at different times.

Even though notes from a 20 January interview with the Lt. Burke indicate that the vessel's speed over ground was only 12 knots, the log entry at the time of the accident confirms that the average speed was actually 14.2 knots. Though there can be many unidentifiable factors that will prevent a vessel from attaining the speed specified by the propeller rotation speed, in this case "*turns for 15 knots*", there are three specific factors that can be identified in this instance. Since the coordinates and times of the location of the accident and the recovery of the carcass are known, average speed of drift of the carcass can be calculated at about 0.35 knots to the north. It can therefore be assumed that the Point Francis was moving against a current generally from the south. The Ship's Log reports that the sea swell was also generally from the south. Also, the vessel was in transit for yard availability. This would imply that there was probably some degree of fouling on the hull which could reduce performance.

Propeller Cut Series I

A photograph of the cuts in Series I (Figure-4) was selected for analysis using unpublished methods developed by this author. Specifically, the analysis was conducted on Cut #13. In this case, Cut #13 was selected because it was the most suitably rendered cut in the photograph. Any cut in the series can be used for this analysis if the series of cuts has been photographed properly. Though a detailed explanation of the methods employed is beyond the scope of this evaluation, the results provide an interesting insight into the specifics of the accident.

The first step in the analysis determined that the cuts in Series I could have been created by any one of the following propeller sizes:

Blades	3	4	5	6
Diameter (cm.)	68.8	91.7	114.6	137.5
Diameter (in.)	27	36	45	54

Table-1: Number of blades and size of propellers that could have created the cuts in Propeller Cut Series I.

The maximum length of cut that each of these propellers could reasonably create was used to eliminate the propellers with 3 and 4 blades. The cord depth that each of the remaining two propellers would produce for each of the cuts in Series I was used to eliminate the propeller with 6 blades. Therefore the cuts in Series I where most probably created by a 114.6 cm (45 inch) diameter propeller with 5 blades. This calculated size is within 7% of the actual size of the propellers on the Point Francis. The method of

analysis employed here also revealed that the Advance Coefficient (J) of the vessel relative to the surface of the animal at Cut #13 was 0.92.

Another method of analysis developed by the author allows the Advance Coefficient (J) of the vessel relative to the surface of the animal to be calculated at each cut in the series (Table-2). Comparing the relative Advance Coefficient calculated using this method for Cut #13 to the previously calculated value confirms that the two methods are in agreement. In both instances the relative Advance Coefficient is 0.92.

Cut #	J	Vessel Relative Speed (knots)	Whale Speed (knots)
3	0.65	14.2	0.0
4	0.66	14.6	0.4
5	0.68	15.0	0.8
6	0.72	16.0	1.8
7	0.77	16.9	2.7
8	0.84	18.5	4.3
9	0.89	19.6	5.4
10	0.92	20.4	6.2
11	0.94	20.8	6.6
12	0.93	20.6	6.4
13	**0.92**	20.2	6.0
14	0.86	19.0	4.8
15	0.86	19.0	4.8

Table-2: Table of Relative Advance Coefficient (J), Relative Vessel Speed, and Whale's Speed through the water.

Once the minimum relative Advance Coefficient for the series is known, 0.65 at Cut #3, it is possible to estimate the pitch of the propeller. For the Point Francis, the pitch of the propeller is probably slightly greater than 29 inches. Changes in the relative advance coefficient can be used to examine changes in the relative speed of the vessel, but it is not usually possible to calculate the actual relative speed of the vessel or the speed of the animal. Fortunately, the Ship's Log for the Point Francis provides enough additional information to allow both of these values to be determined at each cut in the series.

In the Log's Weather Observation and Operational Summary Sheet it is noted that at 1500 hrs the Point Francis had traveled 14.2 nautical miles during the preceding hour. This means that for that time the vessel's average speed was 14.2 knots. In the Log's Remarks Sheet it is noted that at 1348 hrs the propeller shafts' rotations were set at 600 rpm. There is no indication that the rotation speed of the propeller shafts was changed from that time until the whale was struck at 1517 hrs. Therefore, it is only reasonable to assume that the vessel speed was 14.2 knots and the propeller rotation was 600 rpm at the time of the accident. This information allows the calculation of the relative speed of the vessel and the speed of the whale at the time each cut in the series is created (Table-2).

Since the vessel's relative speed is greater than its actual speed, the vessel and whale were traveling in opposite directions. The vessel's approach was from directly in front of the whale (Figure-9).

The direction the vessel crossed the animals body can often be established by examining the shapes of the individual propeller cuts, however there are instances when these shapes can be misleading. The cuts in Series I are an example of just such a case. The drawings of the propeller cuts taken from the necropsy report (Figure-2) provide a reasonable approximation of the shape of the cuts in Series I. Most of these cuts, and especially the cuts along the dorsal caudal ridge, form a crescent shape that would normally be interpreted as indicating the vessel advanced from the tail to the head. Unfortunately, the use of the crescent shape of the cuts as an indicator of the direction of the vessel's advance is only valid when the cuts are very shallow.

Most of the cuts in Series I occur on relatively narrow body sections which results in cuts that are almost as deep as they are long, and when combined with the significant rake angle of the propeller on the Point Francis, this produces cuts with entry and exit points that are well forward of the center of the cut (Figure-5). This creates a geometry which has been appropriately described as the "sliced pickle effect" (Pitchford, 2002). These cuts form a crescent shape which would imply that the vessel was traveling in a direction directly opposite its actual direction of travel. Therefore, only the shapes of very shallow cuts that occur on broad, relatively flat surfaces should be used to establish the direction the vessel traversed the surface, and none of the cuts in Series I are suitable for this purpose. The position and shapes of the cuts do reveal that the propeller was rotating clockwise.

Propeller Cut Series II

None of the photographs of Propeller Cut Series II are suitable for detailed analysis. However, it is possible to use the length of the cuts recorded in the Table of Measurements (Figure-3) to determine that the propeller which created these cuts was at least 139.5 cm (55 inches or 4.6 feet) in diameter. Calculations using the length and depth of the cuts indicate that the propeller was possibly 247 cm (108 inches or 9 feet) in diameter or larger. Both of these methods usually underestimate the diameter of the propeller by a significant margin. A third calculation indicates that the propeller was approximately 484 cm (191 inches, 16 feet) in diameter. Without more suitable photographs of the cuts in Series II it is only reasonable to state that the diameter of the propeller was certainly larger than 139.5 cm (55 inches) and may have been significantly larger than 247 cm (108 inches). Clearly, these cuts were not created by the Point Francis.

Aerial photographs of the carcass taken just before it was recovered (Figure-6) show the carcass floating ventral surface up. The cuts of Propeller Cut Series II are clearly visible along the animal's left side and across the ventral surface of the head. The shape and position of the cuts indicates that the animal was probably floating ventral surface up when the cuts were created. Since right whale carcasses usually float ventral surface up

and it has already been established that the wounds inflicted by the Point Francis very probably were the cause of death, it is reasonable to assume that the cuts of Series II were inflicted postmortem. A microscopic examination of samples of tissue marginal to the cuts could help conclusively establish that these cuts were inflicted postmortem.

The general shape of the cuts gives the impression that the vessel approached the carcass from the animal's left rear (ventral surface up). The path of travel can be more conclusively established by examining the shapes of the very shallow cuts on the ventral surface of the head (Figure-7). Cut #I and Cut #J are very shallow cuts that were created by the very tip of the propeller blade. The crescent shapes of these cuts indicate the vessel's path was from the tail to the head (Figure-10). The shape and position of the cuts in Series II also indicate that the propeller was turning counter clockwise.

Cuts #I and #J also indicate that when the cuts in Series II were created the head of the animal was probably deeper in the water than the rest of the carcass. The caudal side of each of these cuts includes an area where the surface of the animal's skin has been shaved off by the propeller blade. This indicates that the surface of the animal was at a very acute angle to the blade of the propeller. The preceding cuts in the series are unremarkable in this regard and indicate that the surface of the animal was in the more common position which is essentially perpendicular to the blade. This may indicate that the carcass had not filled with enough gases from decomposition to allow the head to float at the same level as the remainder of the body. This information could be helpful in establishing when the collision that created Propeller Cut Series II occurred.

There is another anomaly in Propeller Cut Series II that is very curious. It appears that there may be two series of cuts superimposed one over the other (Figure-8). Cuts A, B, C, D, F, G, and I (referred to as Cuts A-I) are regularly spaced and of similar length and appearance. These cuts also appear to converge at a common point to the left of the vessel's relative path which would represent the center of a radius formed by the relative path of the vessel. Cuts E, F1, H and J (referred to as Cuts E-J) appear to form another series of cuts which more or less converge at a point opposite the center of radius for the other cuts. These cuts are also spaced at regular distances similar to the spacing of Cuts A-I.

Cut #E, which is not properly rendered in the necropsy drawing and is difficult to see in the photographs (Figure-8), is a very shallow cut which lies between two relatively deep cuts. It is also at a significantly different angle indicating that it does not share the radius common to most of Cuts A-I. For a propeller to create a relatively deep cut followed by a shallow cut which is then followed by another relatively deep cut on a fairly even surface would be very unusual. Yet, this accurately describes the relationship between cuts D, E, and F.

Cut #H is a relatively short, shallow cut which lies between two long cuts. It is also at an angle significantly different from Cuts A-I and appears to converge with Cut #E on the side of the carcass opposite the center of the radius formed by Cuts A-I. It would be equally unusual for a propeller to form a relatively long cut followed by a short cut which

is then followed by another relatively long cut on a fairly even surface. Yet, this accurately describes the relationship between cuts G, H, and I.

Cut #I is a relatively long cut which lies between two short cuts. It too forms the unusual pattern of a short cut followed by a long cut followed by a short cut on a fairly even surface.

When all of the cuts in Series II are considered together, the spacing between the cuts from #D to #J appears erratic and uneven. However, if Cuts A-I are considered as one series and Cuts E-J are considered as another series, the spacing is very regular (Table-3) and when the spacing of these two series are compared, they are very similar.

Cuts	Separation (cm)
A - B	29
B - C	40
C - D	40
D - F	59
F - G	50
G - I	35

Cuts	Separation (cm)
E - F1	52
F1 - H	44
H - J	30

Table-3: Table of separations if cuts are considered as two series.

One possible explanation for this unusual pattern of cuts is that the vessel that created the cuts may have had four propellers – two propellers on the port side with one forward of the other and two propellers on the starboard side in the same configuration. Each propeller would be powered by its own shaft and the two propellers on each side of the vessel would rotate the same direction. If the carcass was struck by both propellers on one side of the vessel, and if both shafts were operating in parallel, then the cuts resulting from the two strikes would have essentially the same spacing and could be expected to essentially overlay one another. The suggested scenario is only speculative, but the observed pattern of cuts does appear to support this possibility. It is also possible that the carcass, which drifted through the heavily traveled area of the Jacksonville navigational channel, may have been involved in more than one postmortem strike which resulted in the unusual pattern of cuts seen in Propeller Cut Series II. This is also very speculative, and the only thing that can be stated with certainty is that these cuts were not created by the Point Francis.

Conclusions

The Point Francis created the cuts in Propeller Cut Series I. The analysis indicates that these cuts were created by a propeller with a clockwise rotation that was about 114.6 cm (45 inch) in diameter with 5 blades and a pitch greater than 29 inches. The vessel approached from directly in front of the whale, and the initial strike was in the head at Cut #18. The speed of the whale at the beginning of the accident was about 4.8 knots, and the initial speed of the whale and its path of travel directly under the entire length of the vessel does not indicate a flight response by the calf. After the initial strike, the calf's

speed suddenly increases to about 6.6 knots. About one third through the series of cuts, the whale appears to be incapacitated, and its speed drops off to 0 knots by the end of the series.

The cuts in Propeller Cut Series II were not created by the Point Francis. The analysis indicates that these cuts were created by a propeller or propellers with a counter clockwise rotation and a diameter greater than 139.5 cm (55 inches). The cuts in this series were likely created postmortem. The unknown vessel approached from the left rear with the carcass floating ventral side up.

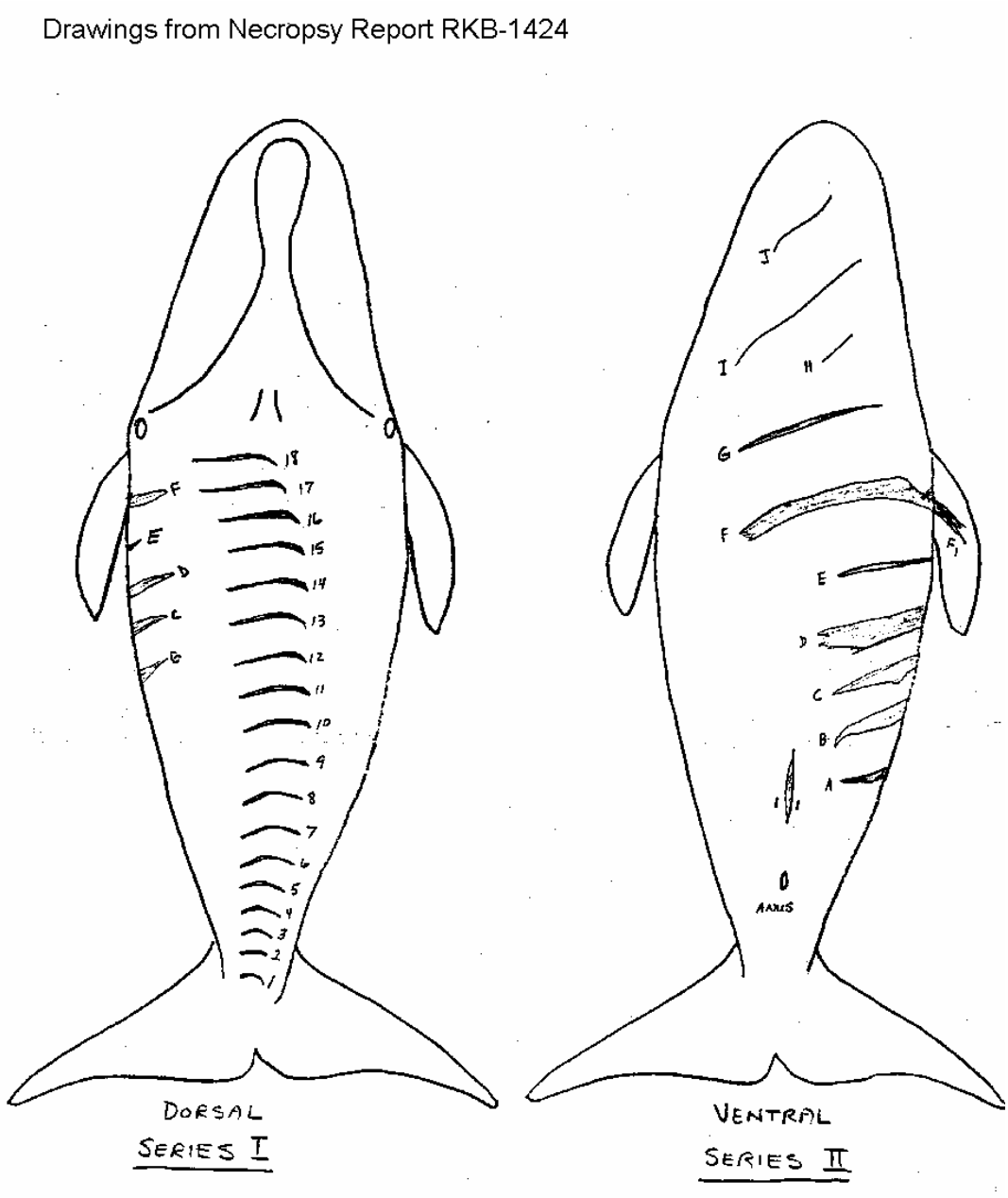

Figure-2: Original drawings from the Necropsy Report RKB-1424

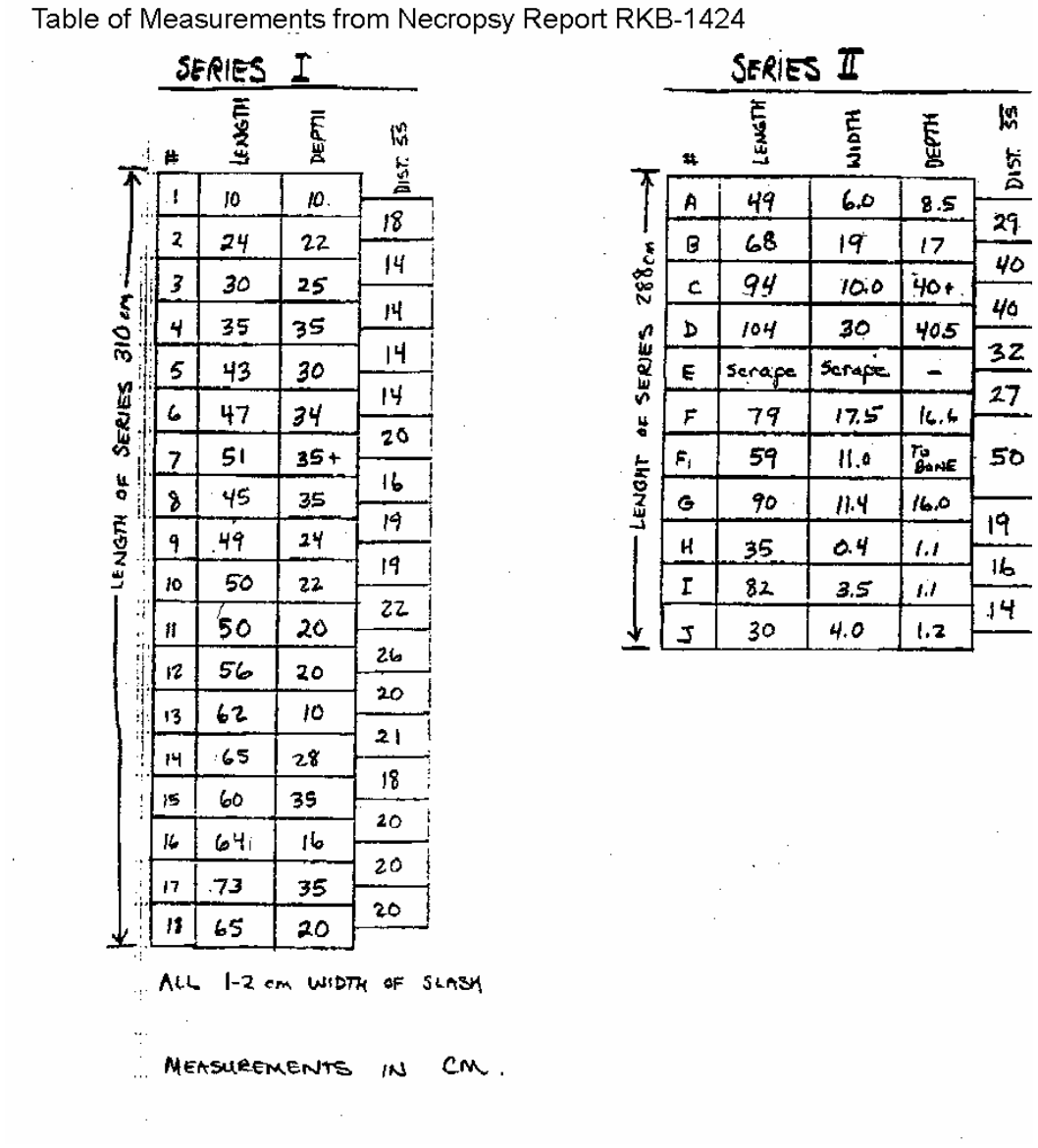

Figure-3: Table of Measurements from the Necropsy Report RKB-1424

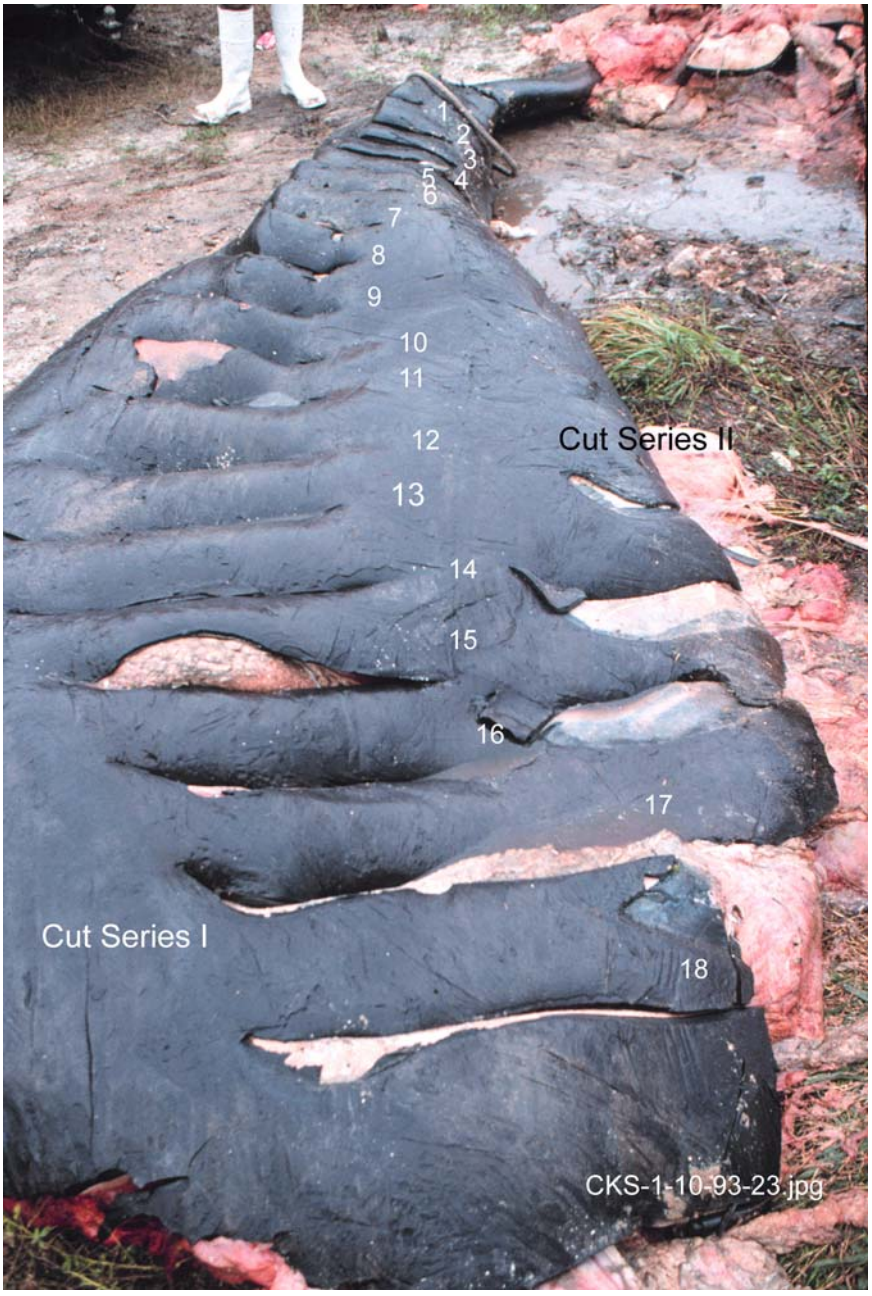

Figure-4: Propeller Cut Series I – Cut #13 was used for detailed analysis. Propeller Cut Series I is to the left of the photograph, and Propeller Cut Series II is to the right.

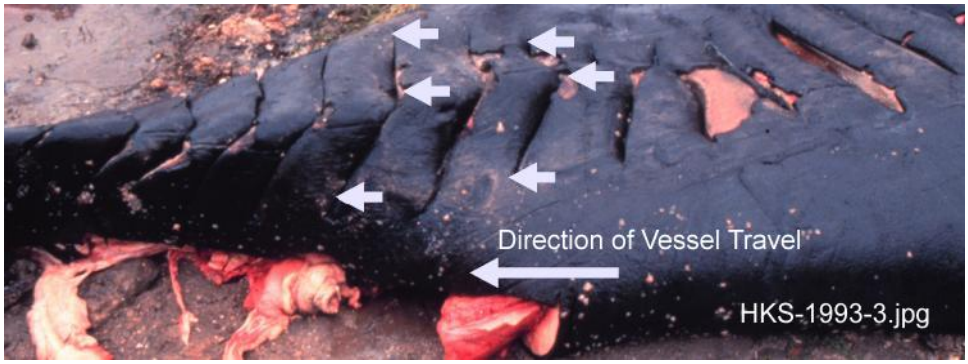

Figure-5: Propeller Cut Series I – The shape of these cuts gives a false impression of the direction the vessel traversed the surface of the animal. Entry and exit points (identified by the arrows at each end of the cuts) are well forward of the center of the cut (identified by the arrow at the center of the cut). The actual direction of the vessel travel is indicated by the large arrow.

Figure-6: Propeller Cut Series II – Aerial view of ventral surface shortly before recovery

Figure-7: Propeller Cut Series II – The shape of very shallow cuts on a relatively flat surface can be used to determine the direction the vessel traversed the body. These cuts indicate the vessel traveled from tail to head.

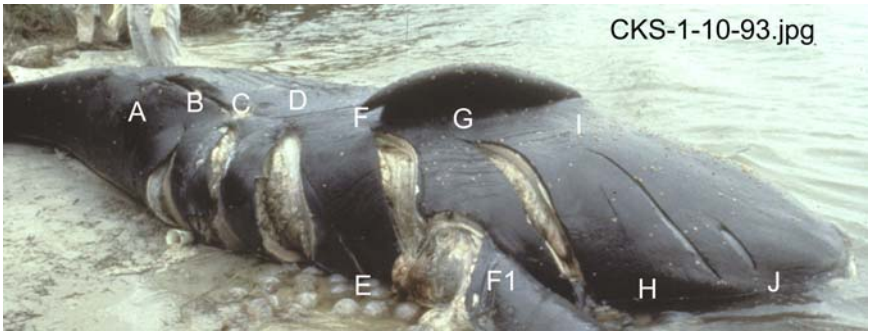

Figure-8: Propeller Cut Series II – Possibly two series of cuts overlying one another

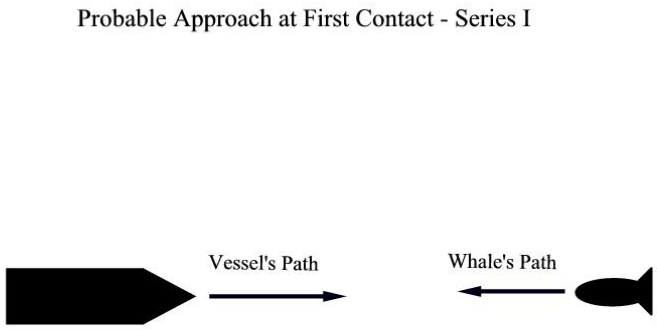

Figure-9: Propeller Cut Series I – Direction of vessel's approach

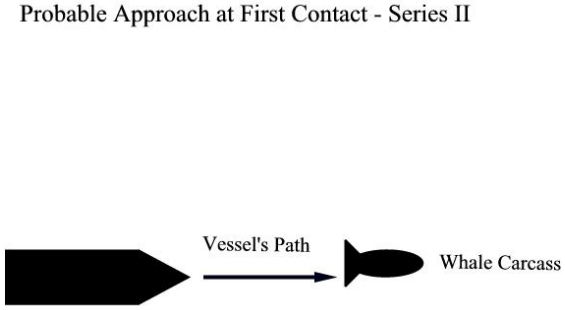

Figure-10: Propeller Cut Series II – Direction of vessel's approach

References

Pitchford, Thomas D., 2002, Marine Mammal Pathobiology Laboratory, Florida Wildlife Research Institute; Personal Discussions

Acknowledgments

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