BONE AGING FILE
1970s - 1980s G. BALAZS

National Museum of Natural History • Smithsonian Institution
WASHINGTON, D.C. 20560

April 24, 1985

Dr. George Balazs
U.S. Dept. of Commerce, NOAA
National Marine Fisheries Service
D/swc2
P.O. Box 3830
Honolulu, Hawaii 96812

Dear George:

The research jewels arrived safely and will go to histology by end of week. She is currently bur ied under with bird eyeballs and whale testes. She should start cutting the Chelonia by mid May. If my summer field work collapses - as I anticipate - expect some results by mid August. Your gentle prodding will be expected.

Yes, please do send me a small series of Hawaiian hatchlings for histology and humerus examination.

Cordially,

George

George R. Zug
Curator
Division of Amphibians
and Reptiles

Zug:NHB Stop 162

NATIONAL MARINE FISHERIES SERVICE
HONOLULU LABORATORY
P. O. BOX 3830
HONOLULU, HAWAII 96812

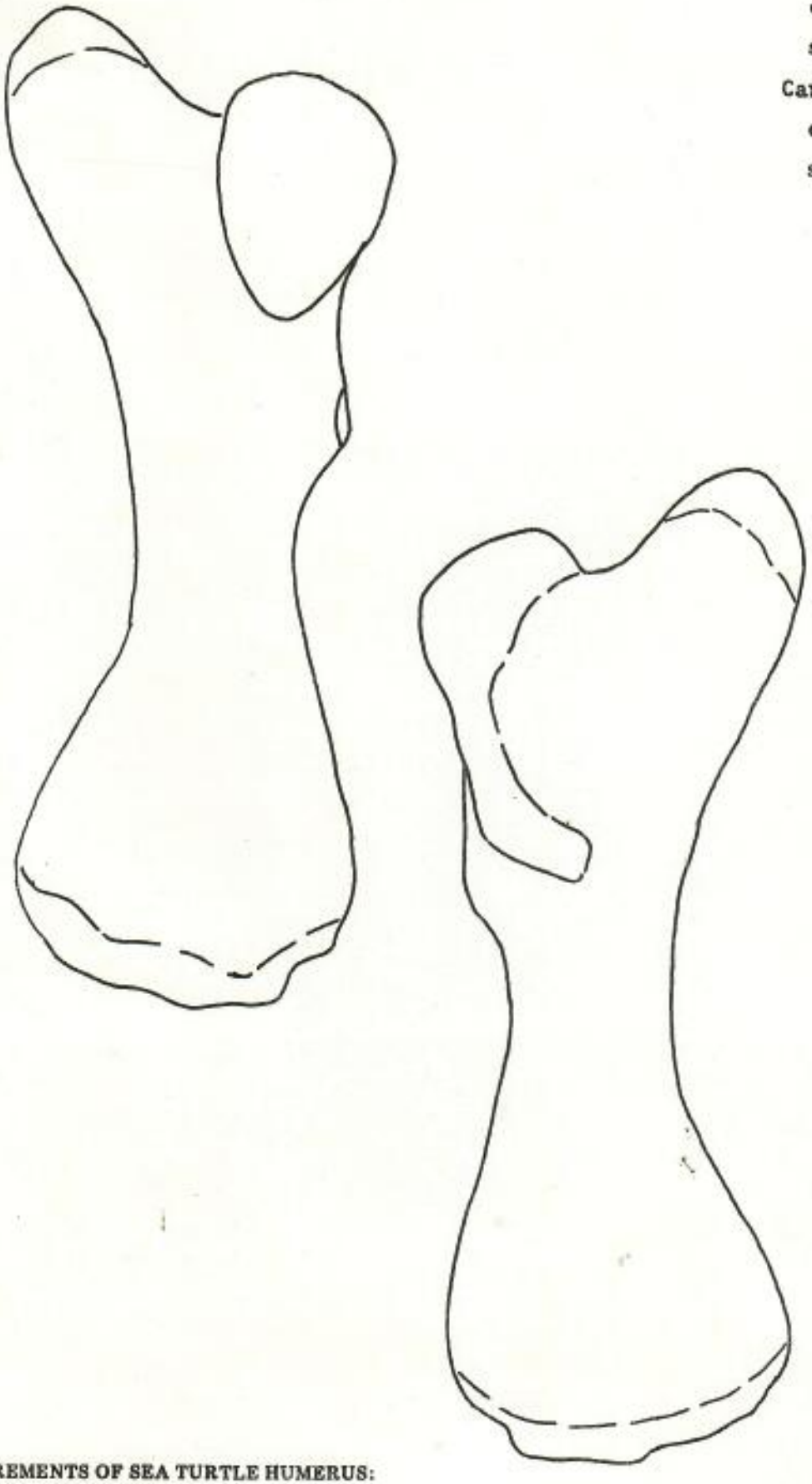
SKELETAL SPECIMENS FOR AGE ESTIMATION OF HAWAIIAN GREEN TURTLES (collected by George H. Balazs)

Specimen numbers	Maximum length (mm)	Weight (g)
Right humerus		
1. Lanai 2-25-85	72	14.0
2. Kaneohe 2-5-85	77	15.0
3. Kure Atoll 10-85	82	16.0
4. Gary 1980	84	19.0
5. Kaneohe 6-2-82	87	22.5
6. Kau 3	95	25.0
7. Kau 4	103	28.5
8. Bellows 5-14-80	106	40.0
9. Kawela 3-29-85	117	47.0
10. Hirota 1980	155	87.0
11. Kauai 3-6-85	168	111.0
12. Kaneohe 3-14-85	172	118.0
13. Kaneohe 28 Nov 84	172	149.0
14. Kahala 3-10-85	181	220.5
15. Laysan 9-78	194	181.0
16. Maui 7-27-84	197	198.0
17. Midway 5-84	212	212.0
18. FFS Tiger	--	115.0
Left humerus		
19. FFS 6-80	194	203.0
20. Kaalualu 5-77	197	145.5
21. Lisianski 9-78	203	223.0

+ SEVERAL HATCHLING PRESERVED IN FORMALYN SENT AT A LATER DATE

Species C. mydas Museum # LANAI 2-25-85 (RIGHT) Sex

Carapace length
curve
straight 37.5
Carapace width
curve
straight 29.8



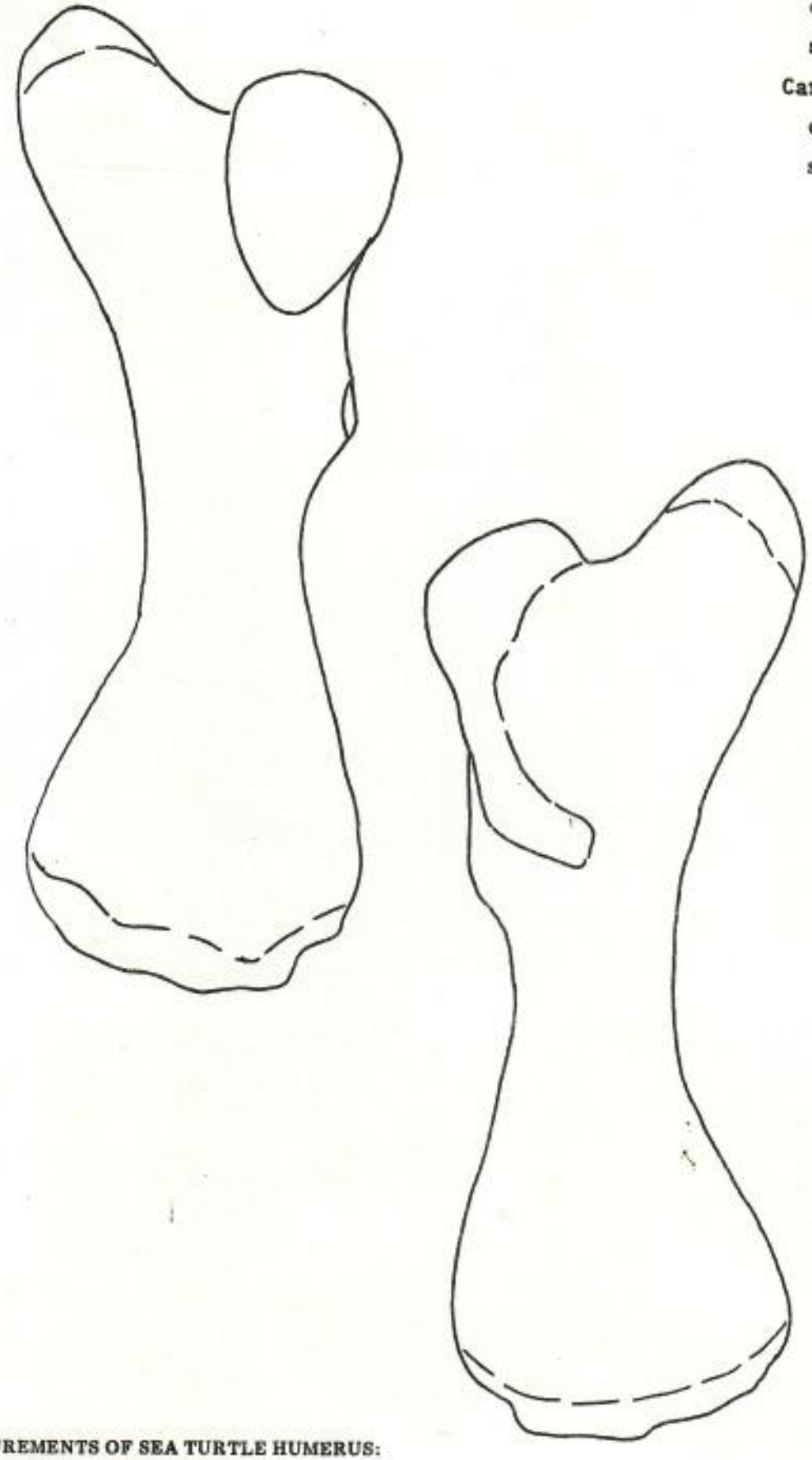
ML	7.2
LL	6.8
UPL	6.8
PL	
PW	
DPCL	
DPPW	
MW	
DW	
MaxHD	
MinHD	
T	
Wt	14.0

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
National Museum of Natural History

Species C. mydas Museum # KANEOHE 2-5-85 (RIGHT) Sex

Carapace length
curve
straight 39.5
Carapace width
curve
straight 33.8



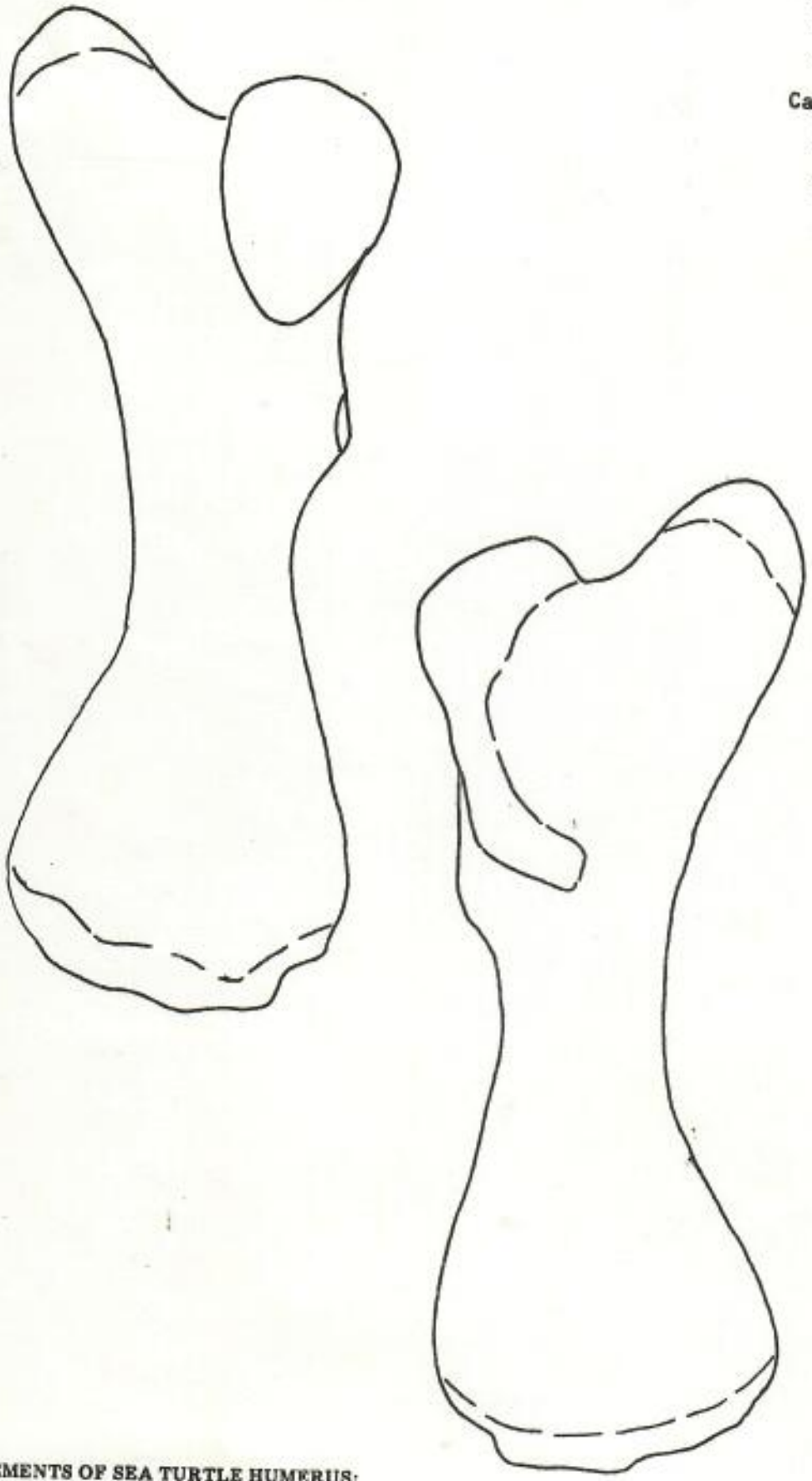
ML	7.7
LL	7.1
UPL	7.0
PL	
PW	
DPCL	
DPPW	
MW	
DW	
MaxHD	
MinHD	
T	
Wt	15.0

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
National Museum of Natural History

Species C. mydas Museum # KURE 10-85 (RIGHT) Sex ____

Carapace length
curve 42.0
straight 39.9
Carapace width
curve 38.4
straight 33.7



ML 8.2
LL 7.6
UPL 7.5
PL
PW
DPCL
DPPW
MW
DW
MaxHD
MinHD
T
Wt 16.0

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
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National Museum of Natural History

Species C. mydas Museum # GARY 1980 (RIGHT) Sex

Carapace length

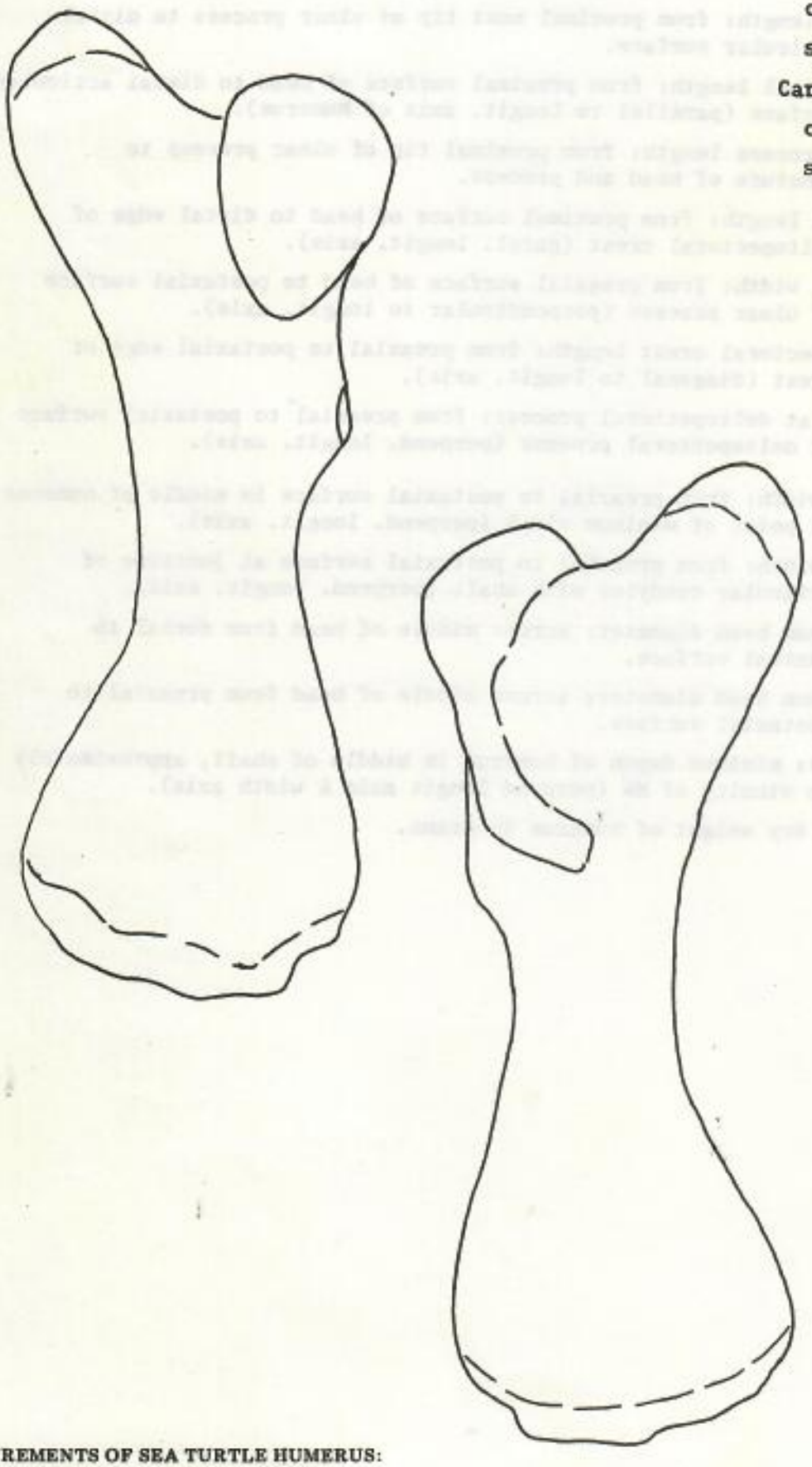
curve

straight

Carapace width

curve

straight



ML 8.4

LL 7.8

UPL 7.7

PL

PW

DPCL

DPPW

MW

DW

MaxHD

MinHD

T

Wt 19.0 g

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
National Museum of Natural History

Measurements of sea turtle humerus: all straight line distances, in mm.

ML, Maximum length: from proximal most tip of ulnar process to distal articular surface.

LL, Longitudinal length: from proximal surface of head to distal articular surface (parallel to longit. axis of humerus).

UPL, Ulnar process length: from proximal tip of ulnar process to juncture of head and process.

PL, Proximal length: from proximal surface of head to distal edge of deltopectoral crest (paral. longit. axis).

PW, Proximal width: from preaxial surface of head to postaxial surface of ulnar process (perpendicular to longit. axis).

DPCL, Deltopectoral crest length: from preaxial to postaxial edge of crest (diagonal to longit. axis).

DPPW, Width at deltopectoral process: from preaxial to postaxial surface at deltopectoral process (perpend. longit. axis).

MW, Medial width: from preaxial to postaxial surface in middle of humerus at point of minimum width (perpend. longit. axis).

DW, Distal width: from preaxial to postaxial surface at juncture of articular condyles with shaft (perpend. longit. axis).

MaxHD, Maximum head diameter: across middle of head from dorsal to ventral surface.

MinHD, Minimum head diameter: across middle of head from preaxial to postaxial surface.

T, Thickness: minimum depth of humerus in middle of shaft, approximately in vincity of MW (perpend longit axis & width axis).

Wt, Weight: dry weight of humerus in grams.

/drawing on reverse based on Caretta humerus/

Species C. mydas Museum # KANEOHE 6-2-82 (RIGHT) Sex

Carapace length

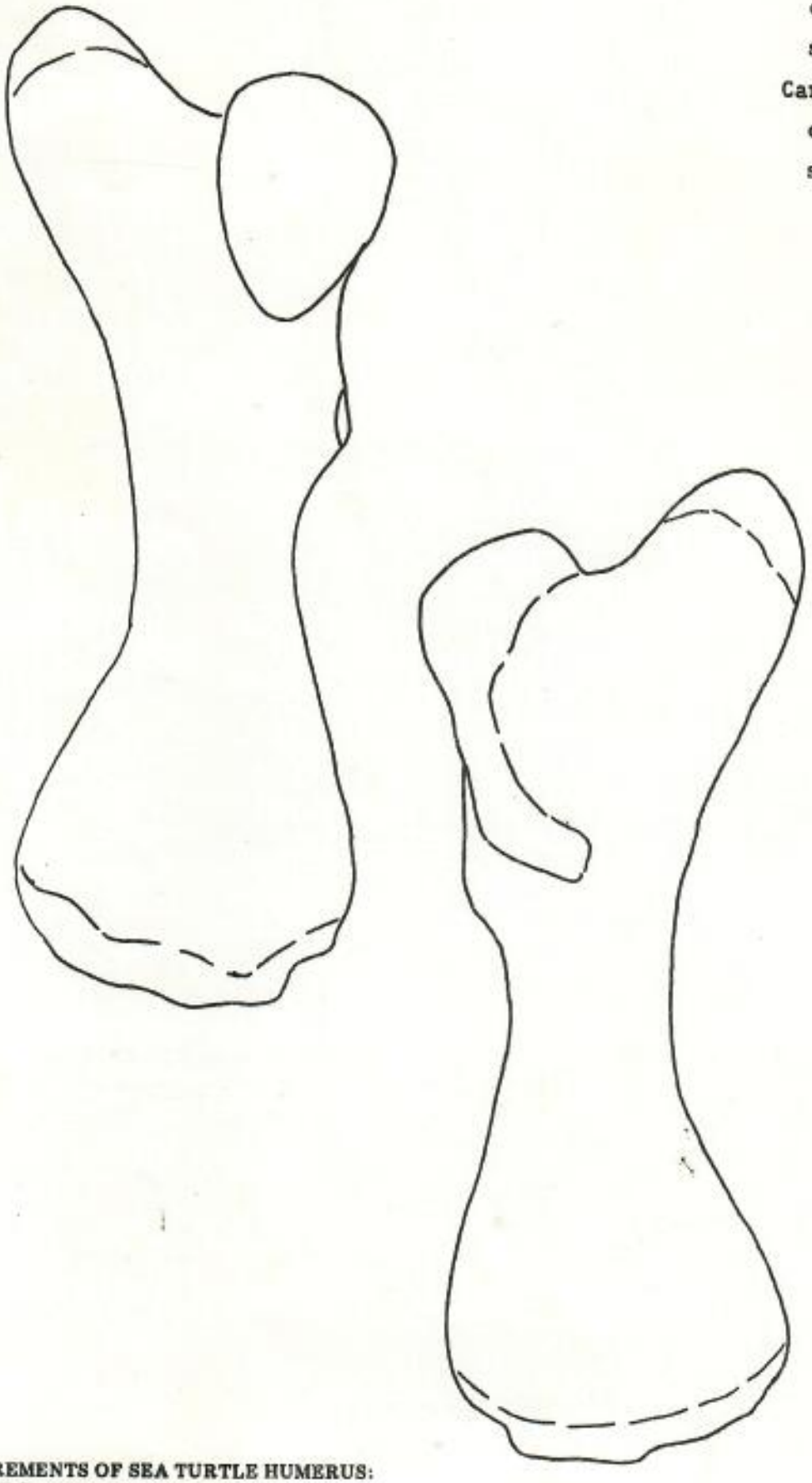
curve

straight 50.8

Carapace width

curve

straight 40.0



ML 8.7

LL 8.15

UPL 8.1

PL

PW

DPCL

DPPW

MW

DW

MaxHD

MinHD

T

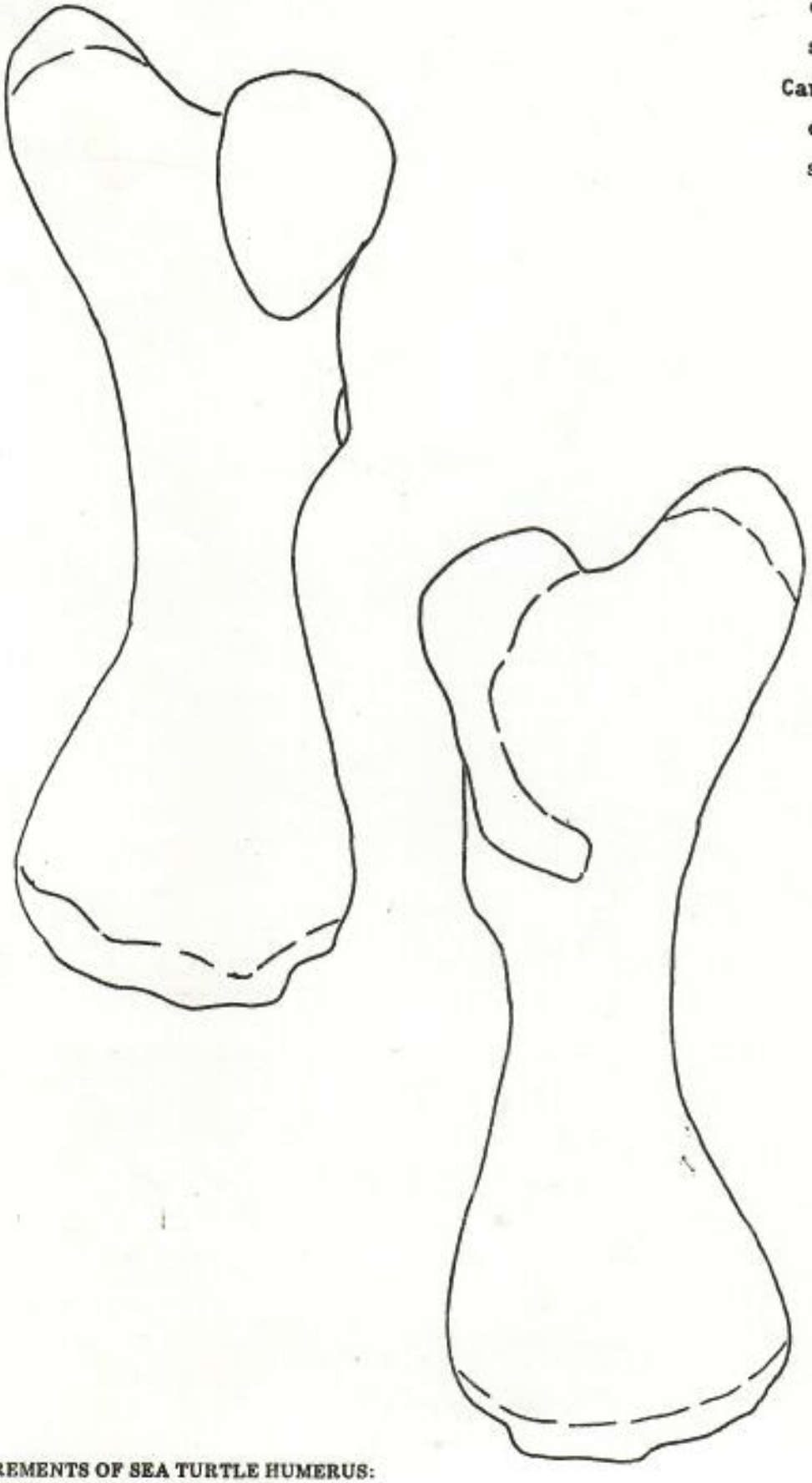
Wt 22.5

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
National Museum of Natural History

Species C. mydas Museum # 3KAU (RIGHT) Sex

Carapace length
curve
straight 47.0
Carapace width
curve
straight



ML 9.5
LL 9.0
UPL 8.8
PL
PW
DPCL
DPPW
MW
DW
MaxHD
MinHD
T
Wt 25.0

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

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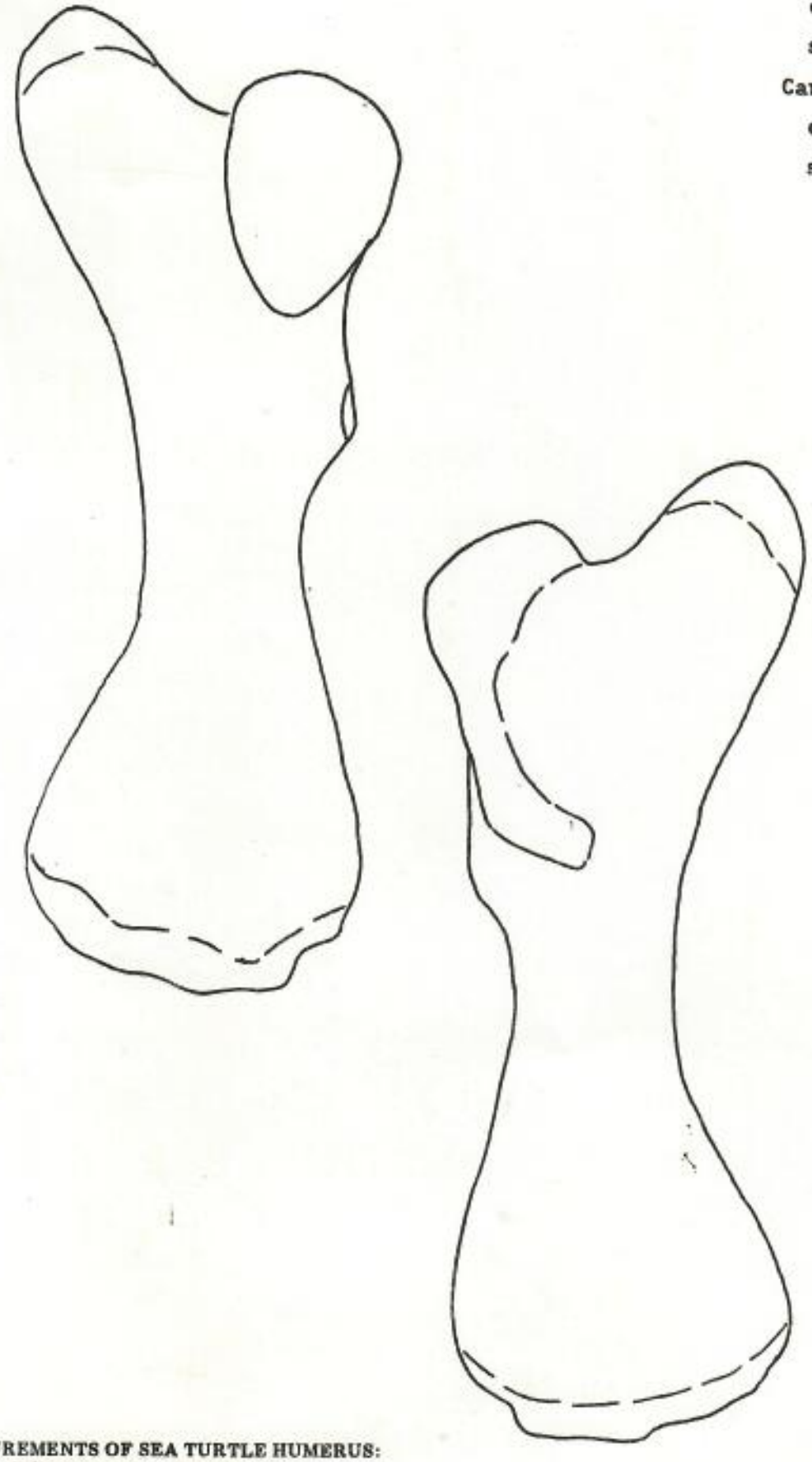
Reptiles/Amphibians
Dept of Vertebrate Zoology
National Museum of Natural History

Species C. mydas Museum # 4 KAU (RIGHT) Sex ____

Carapace length
curve ____
straight 48.2

Carapace width
curve ____
straight ____



ML 10.3
LL 9.7
UPL 9.5
PL ____
PW ____
DPCL ____
DPPW ____
MW ____
DW ____
MaxHD ____
MinHD ____
T ____
Wt 28.5 g

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
National Museum of Natural History

Species C. mydas Museum # BELLOWS 5-14-80 (RIGHT) Sex ____

Carapace length

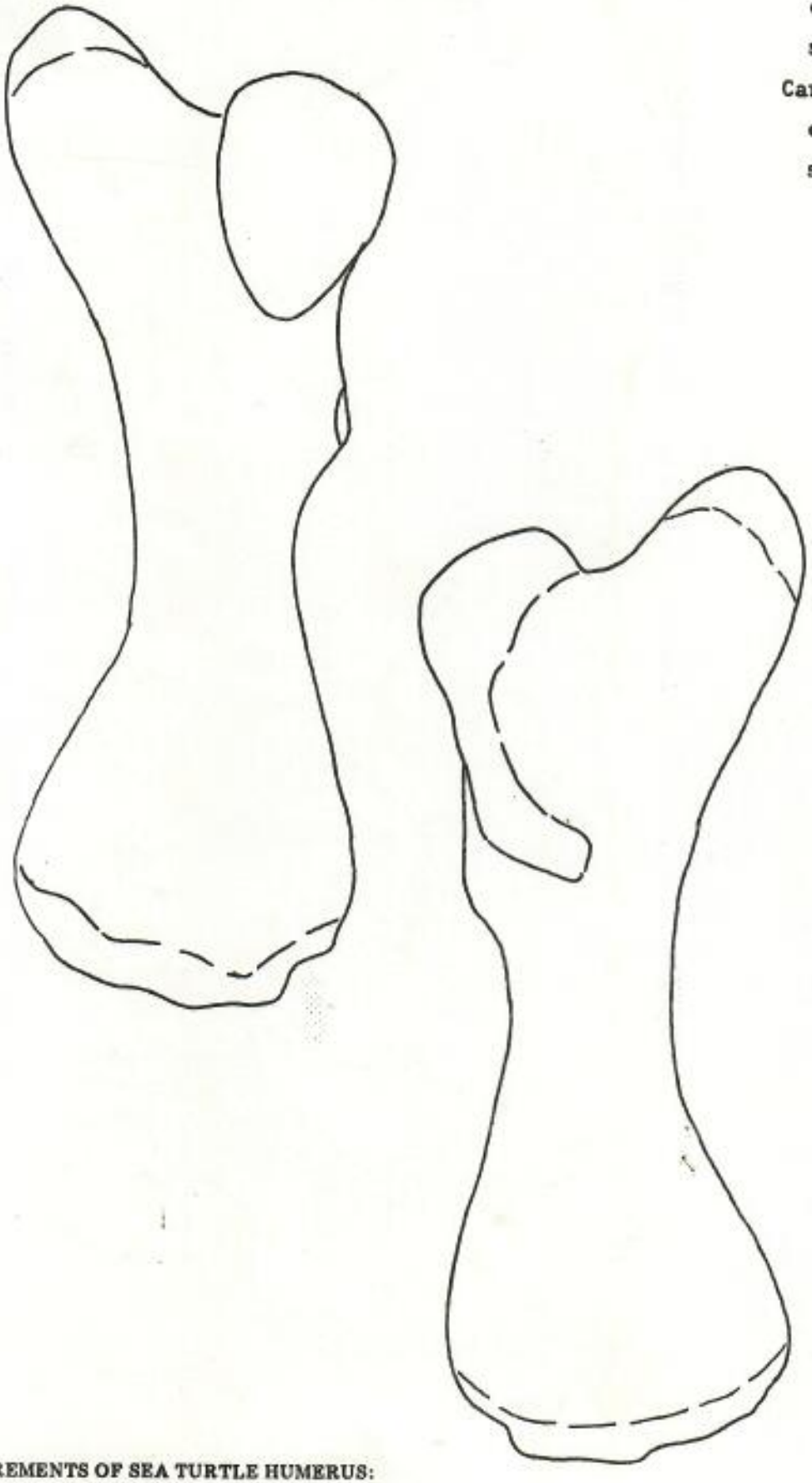
curve ____

straight ____

Carapace width

curve ____

straight ____



ML	10.6 cm
LL	10.0
UPL	9.9
PL	
PW	
DPCL	
DPPW	
MW	
DW	
MaxHD	
MinHD	
T	
Wt	40.0 g

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
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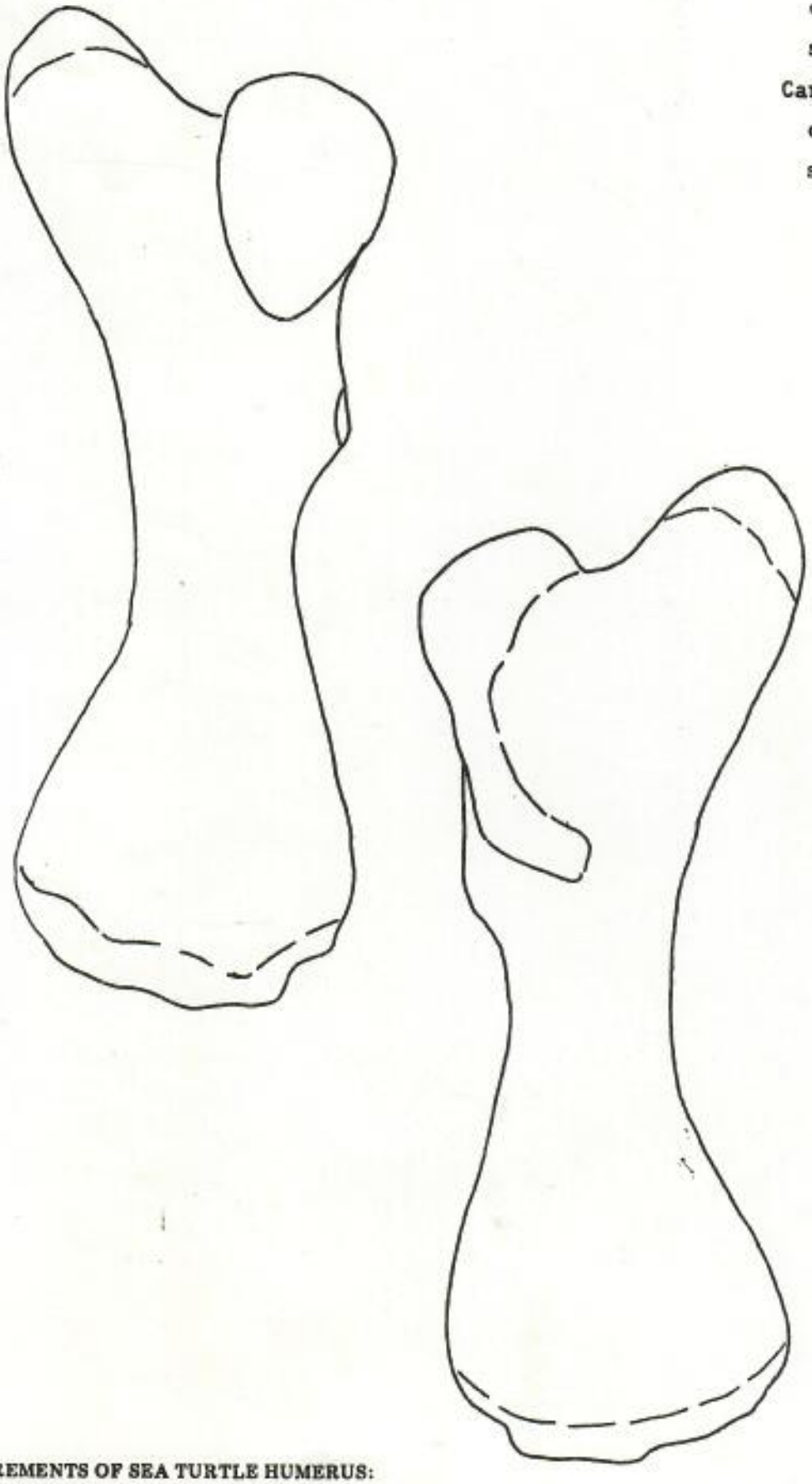
Species C. mydas Museum # KAWELA 3-29-85 (RIGHT) Sex ____

Carapace length
curve ____
straight ____
Carapace width
curve ____
straight ____



ML	11.7
LL	11.0
UPL	10.8
PL	
PW	
DPCL	
DPPW	
MW	
DW	
MaxHD	
MinHD	
T	
Wt	47.0

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
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Species C. mydas Museum # HIROTA 1980 (RIGHT) Sex

Carapace length

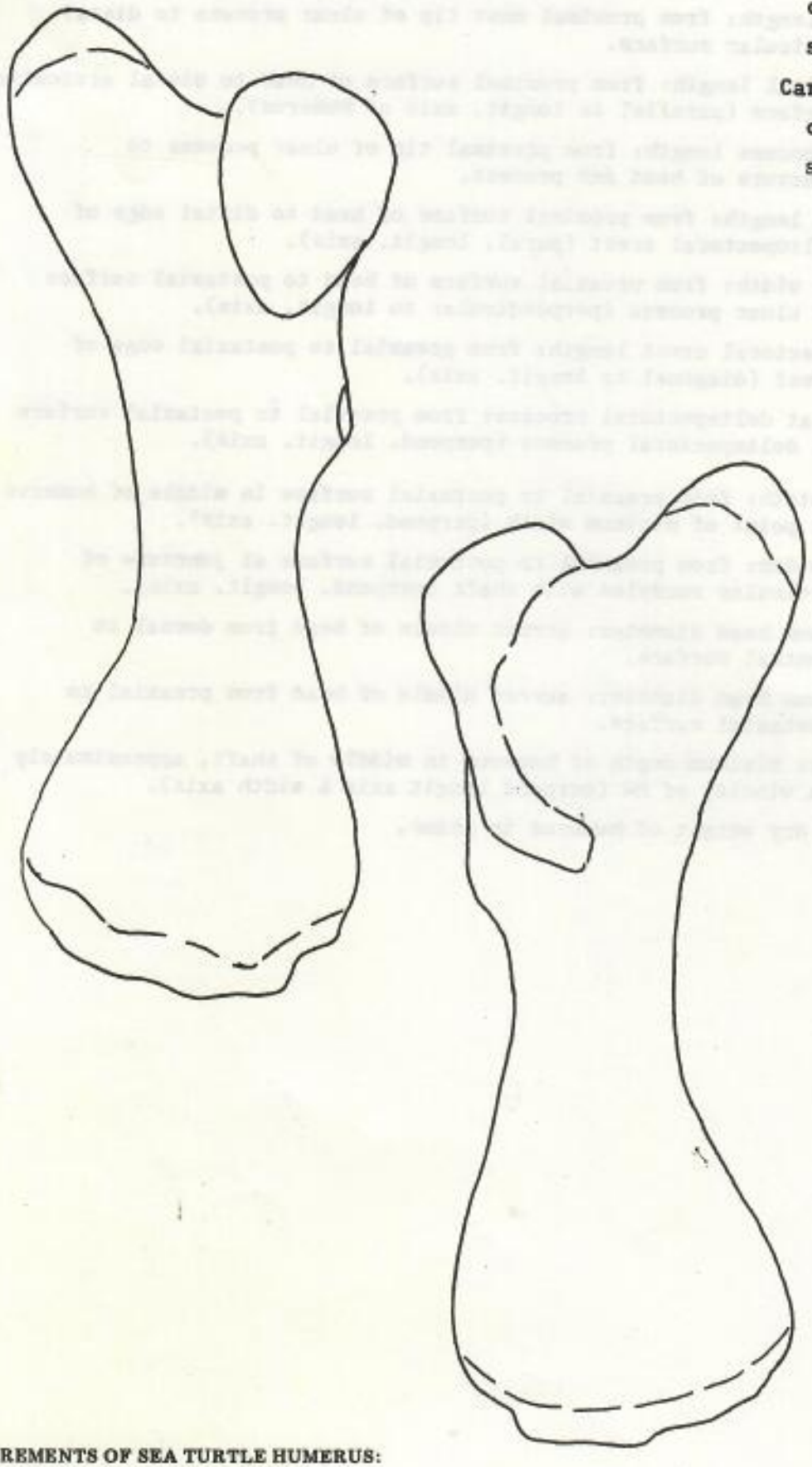
curve

straight

Carapace width

curve

straight



ML 15.5

LL 14.4

UPL 14.2

PL

PW

DPCL

DPPW

MW

DW

MaxHD

MinHD

T

Wt 87.0

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

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Reptiles/Amphibians
Dept of Vertebrate Zoology
National Museum of Natural History

Measurements of sea turtle humerus: all straight line distances, in mm.

ML, Maximum length: from proximal most tip of ulnar process to distal articular surface.

LL, Longitudinal length: from proximal surface of head to distal articular surface (parallel to longit. axis of humerus).

UPL, Ulnar process length: from proximal tip of ulnar process to juncture of head and process.

PL, Proximal length: from proximal surface of head to distal edge of deltopectoral crest (paral. longit. axis).

PW, Proximal width: from preaxial surface of head to postaxial surface of ulnar process (perpendicular to longit. axis).

DPCL, Deltopectoral crest length: from preaxial to postaxial edge of crest (diagonal to longit. axis).

DPPW, Width at deltopectoral process: from preaxial to postaxial surface at deltopectoral process (perpend. longit. axis).

MW, Medial width: from preaxial to postaxial surface in middle of humerus at point of minimum width (perpend. longit. axis).

DW, Distal width: from preaxial to postaxial surface at juncture of articular condyles with shaft (perpend. longit. axis).

MaxHD, Maximum head diameter: across middle of head from dorsal to ventral surface.

MinHD, Minimum head diameter: across middle of head from preaxial to postaxial surface.

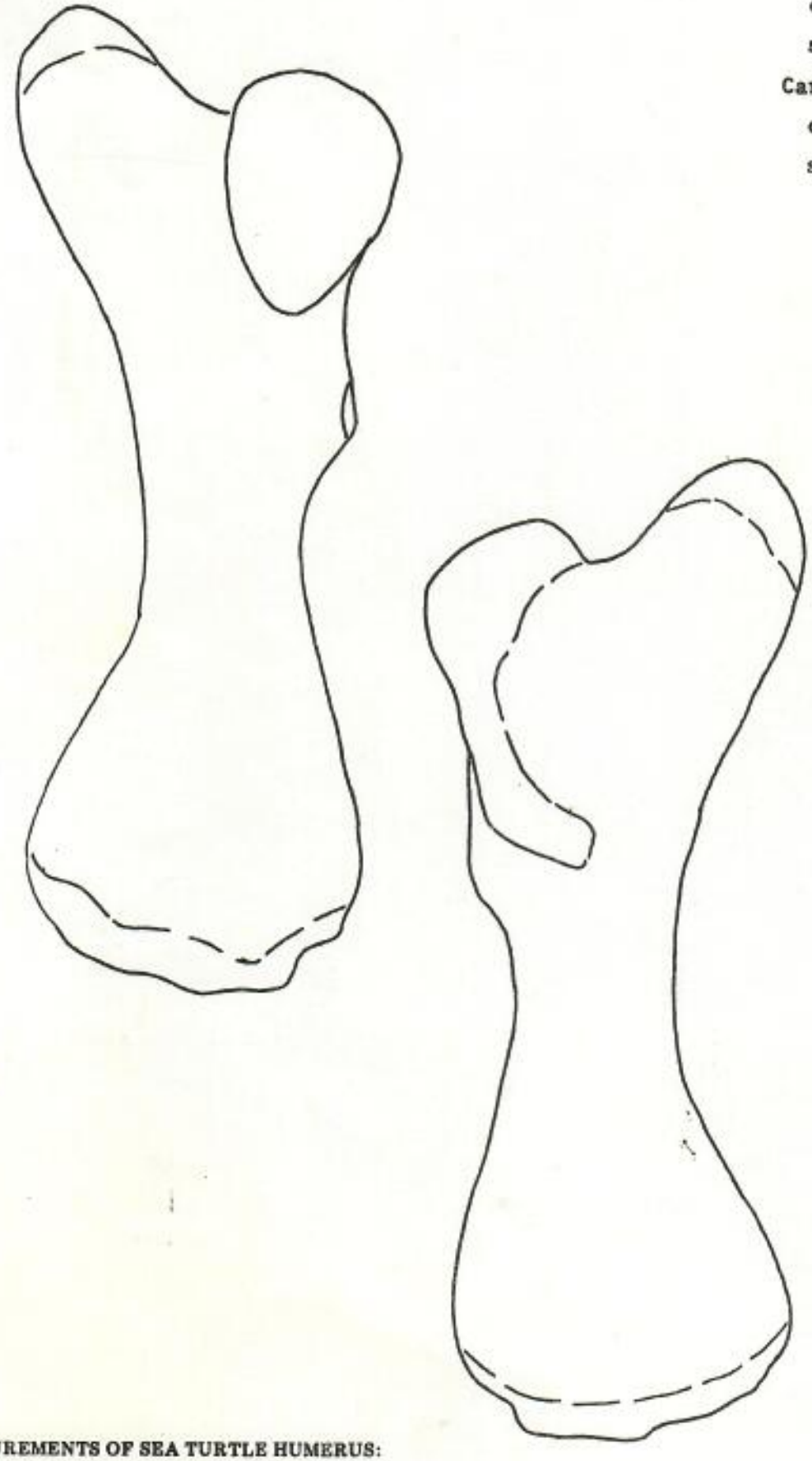
T, Thickness: minimum depth of humerus in middle of shaft, approximately in vincity of MW (perpend longit axis & width axis).

Wt, Weight: dry weight of humerus in grams.

/drawing on reverse based on Caretta humerus/

Species C. mydas Museum # KAUAI 3-6-85 (RIGHT) Sex ____

Carapace length
curve ____
straight ____
Carapace width
curve ____
straight ____



ML	16.8
LL	15.7
UPL	15.4
PL	
PW	
DPCL	
DPPW	
MW	
DW	
MaxHD	
MinHD	
T	
Wt	111.0

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
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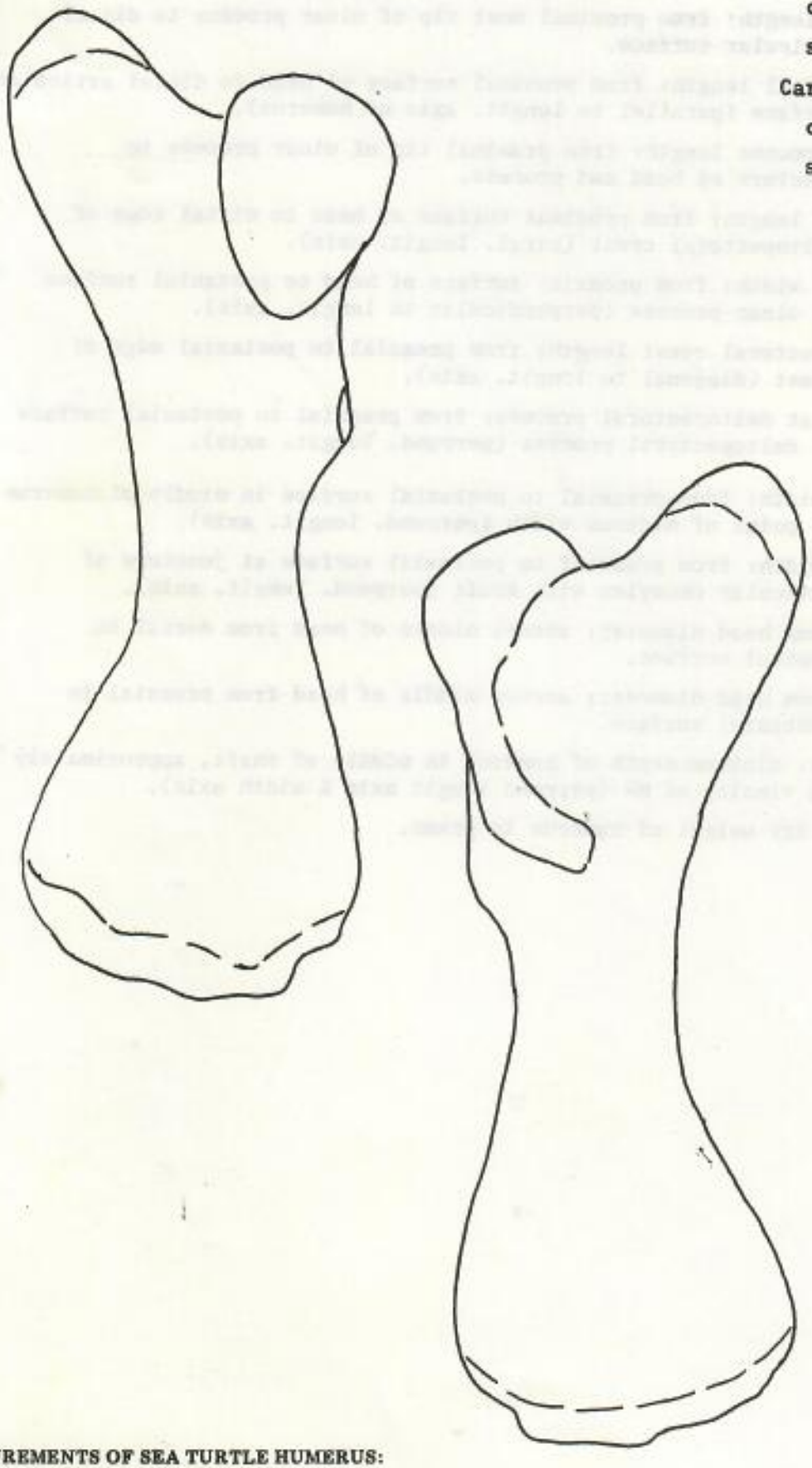
Species C. mydas Museum # KANGOHE 3-14-85 (RIGHT) Sex

Carapace length
curve
straight 74.3

Carapace width
curve
straight 59.9



ML 17.2
LL 15.7
UPL 15.5
PL
PW
DPCL
DPPW
MW
DW
MaxHD
MinHD
T
Wt 118.0 g

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

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Reptiles/Amphibians
Dept of Vertebrate Zoology
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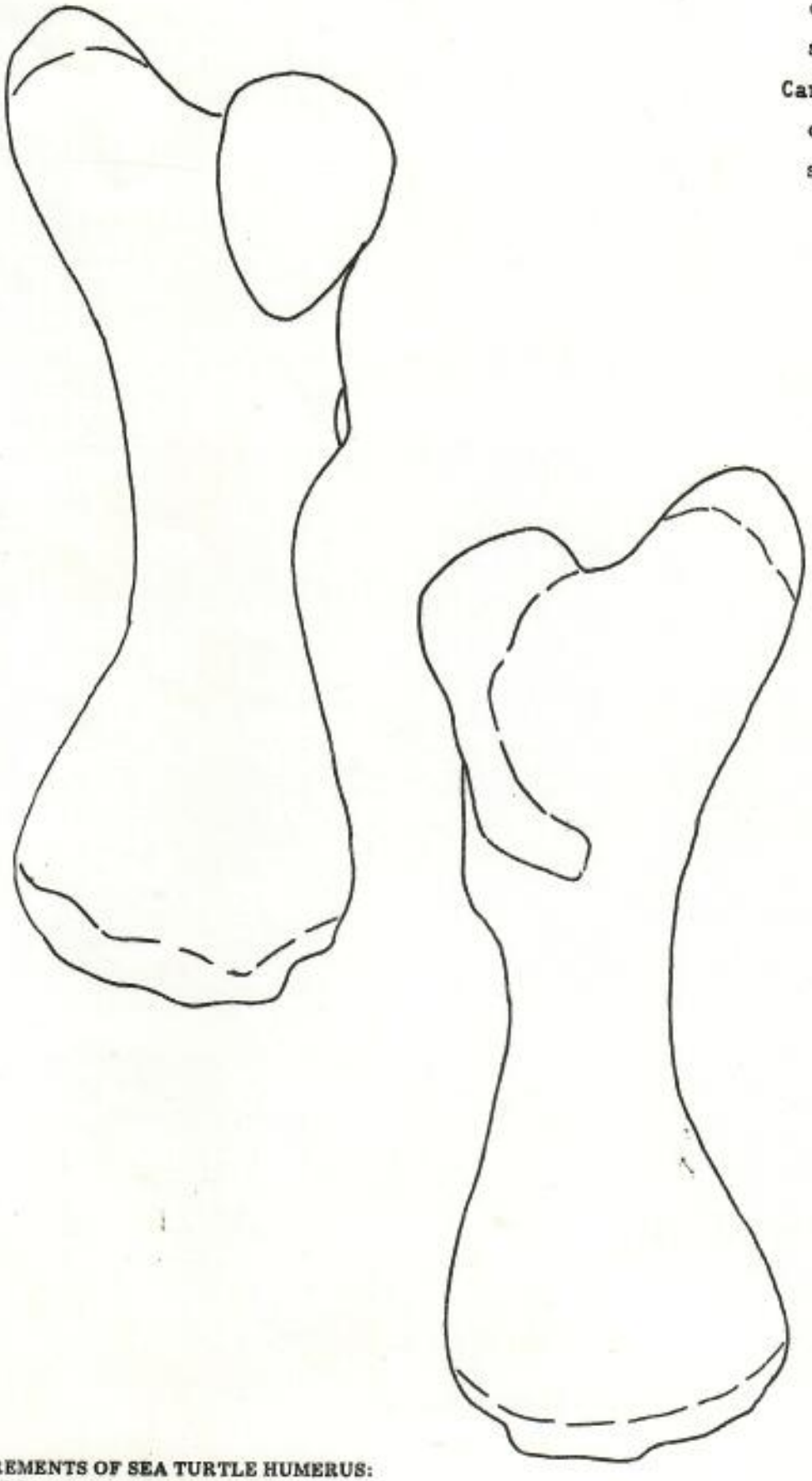
Species C. mydas Museum # KANEOHE 28 NOV 84 (RIGHT) Sex F

Carapace length
curve
straight
Carapace width
curve
straight



ML 17.2 cm
LL 15.9
UPL 15.7
PL
PW
DPCL
DPPW
MW
DW
MaxHD
MinHD
T
Wt 149.0g

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
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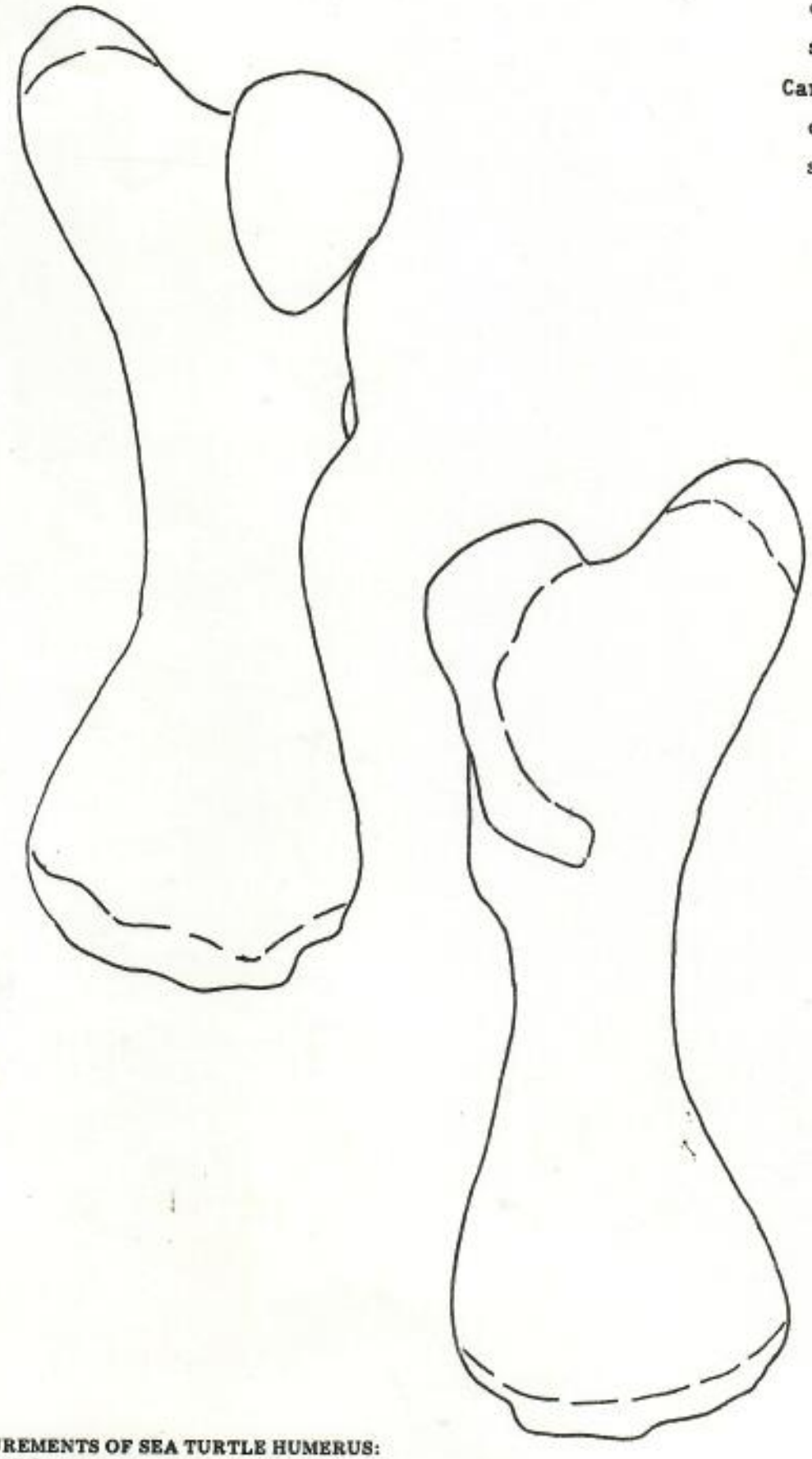
Species C. mydas Museum # KAHALA 3-10-85 (RIGHT) Sex F

Carapace length
curve
straight 82.5
Carapace width
curve
straight



ML	18.1
LL	16.6
UPL	16.2
PL	
PW	
DPCL	
DPPW	
MW	
DW	
MaxHD	
MinHD	
T	
Wt	220.5

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

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Reptiles/Amphibians
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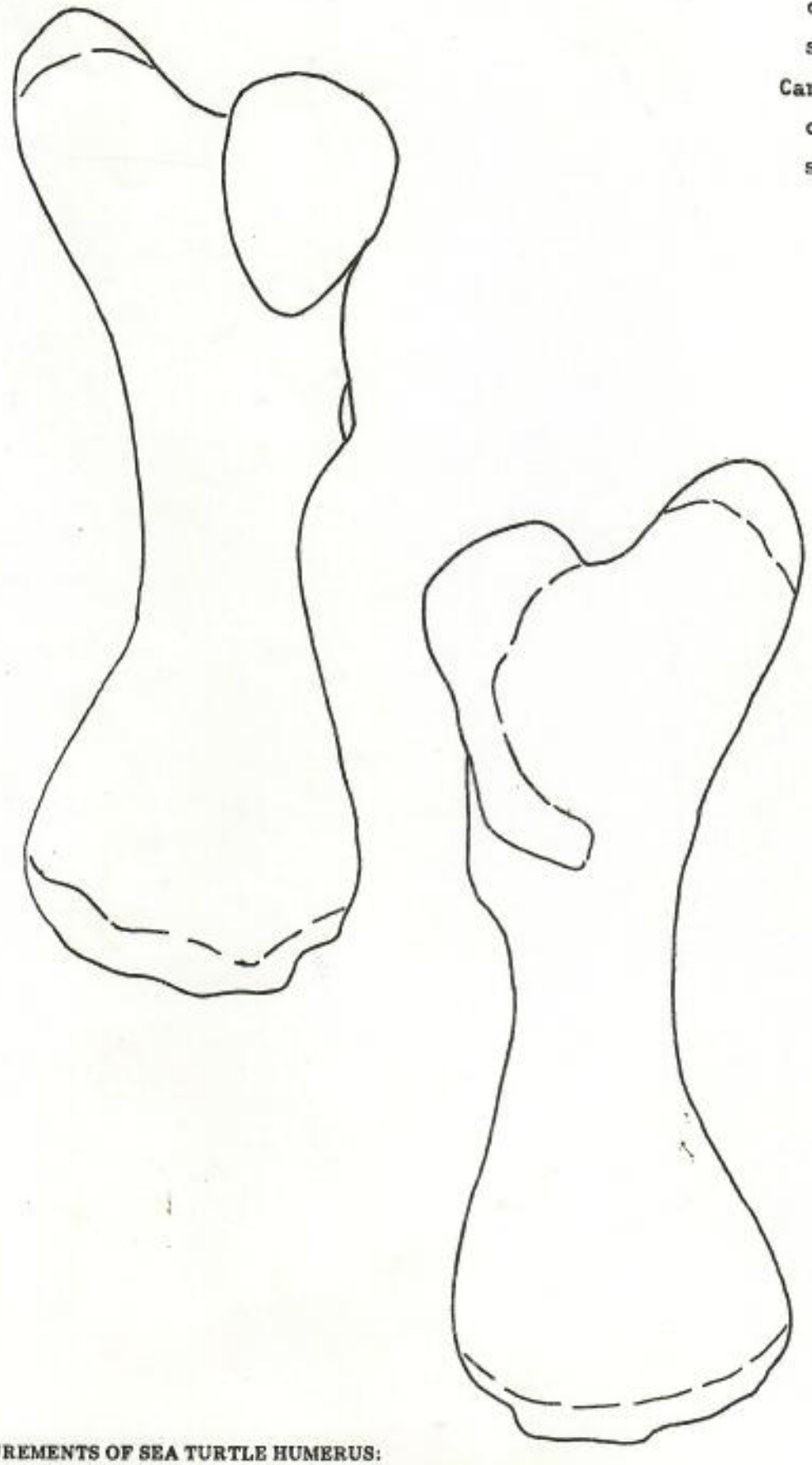
Species C. mydas Museum # LAYSAN 9-78 (RIGHT) Sex ____

Carapace length
curve ____
straight ____
Carapace width
curve ____
straight ____



ML 19.4 cm
LL 18.1
UPL 17.8
PL ____
PW ____
DPCL ____
DPPW ____
MW ____
DW ____
MaxHD ____
MinHD ____
T ____
Wt 181.0g

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
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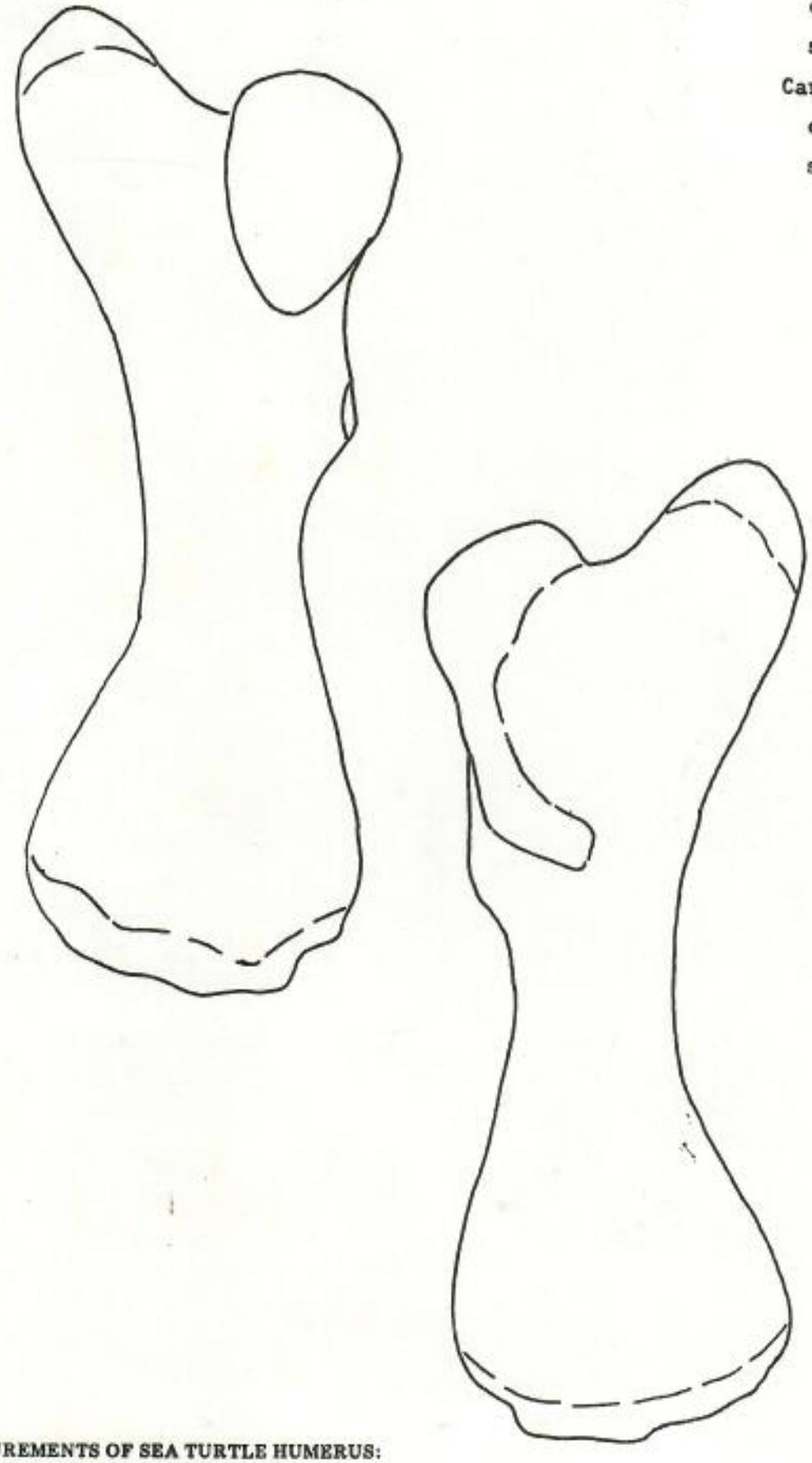
Species C. mydas Museum # MAUI 7-27-84 (RIGHT) Sex ____

Carapace length
curve ____
straight ____
Carapace width
curve ____
straight ____



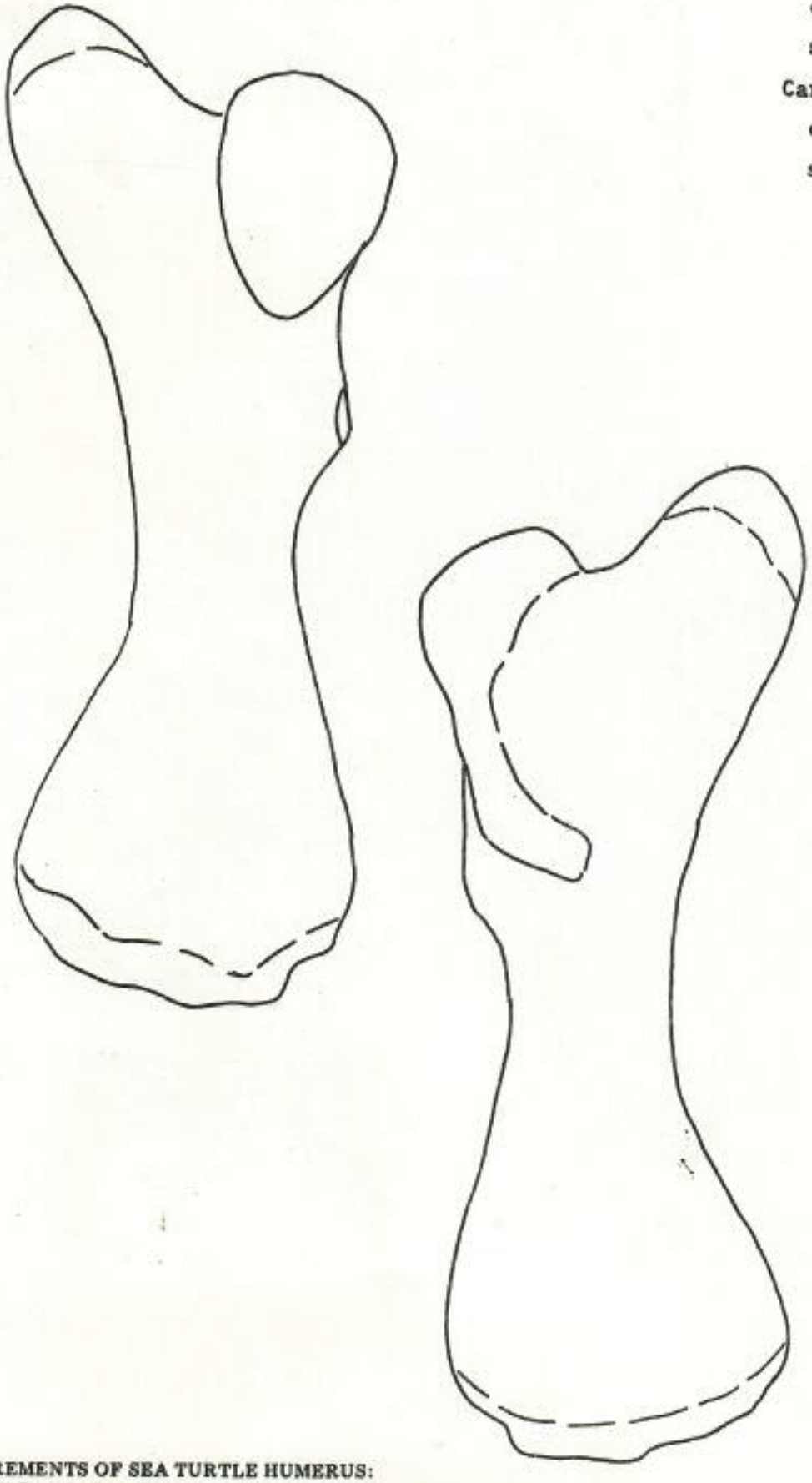
ML 19.7
LL 18.0
UPL 17.5
PL ____
PW ____
DPCL ____
DPPW ____
MW ____
DW ____
MaxHD ____
MinHD ____
T ____
Wt 198.0

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
National Museum of Natural History

Species C. mydas Museum # MIDWAY 5-84 (RIGHT) Sex M

Carapace length
curve
straight
Carapace width
curve
straight



ML	21.2
LL	19.4
UPL	19.0
PL	
PW	
DPCL	
DPPW	
MW	
DW	
MaxHD	
MinHD	
T	
Wt	212.0

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
National Museum of Natural History

Species _____ Museum # FFS TIGER (RIGHT) Sex _____

Carapace length

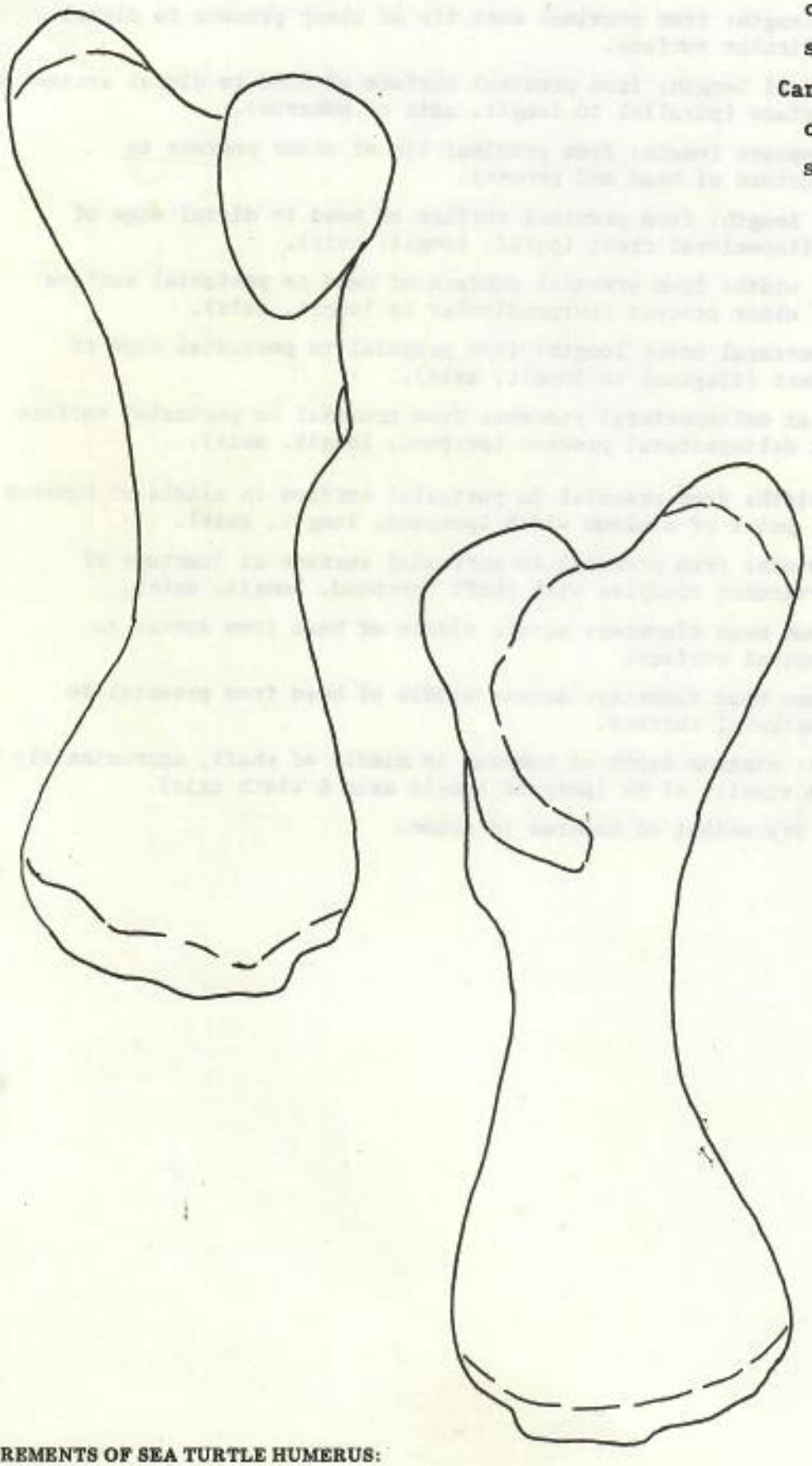
curve _____

straight _____

Carapace width

curve _____

straight _____



ML _____

LL _____

UPL _____

PL _____

PW _____

DPCL _____

DPPW _____

MW _____

DW _____

MaxHD _____

MinHD _____

T _____

Wt 115. g

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
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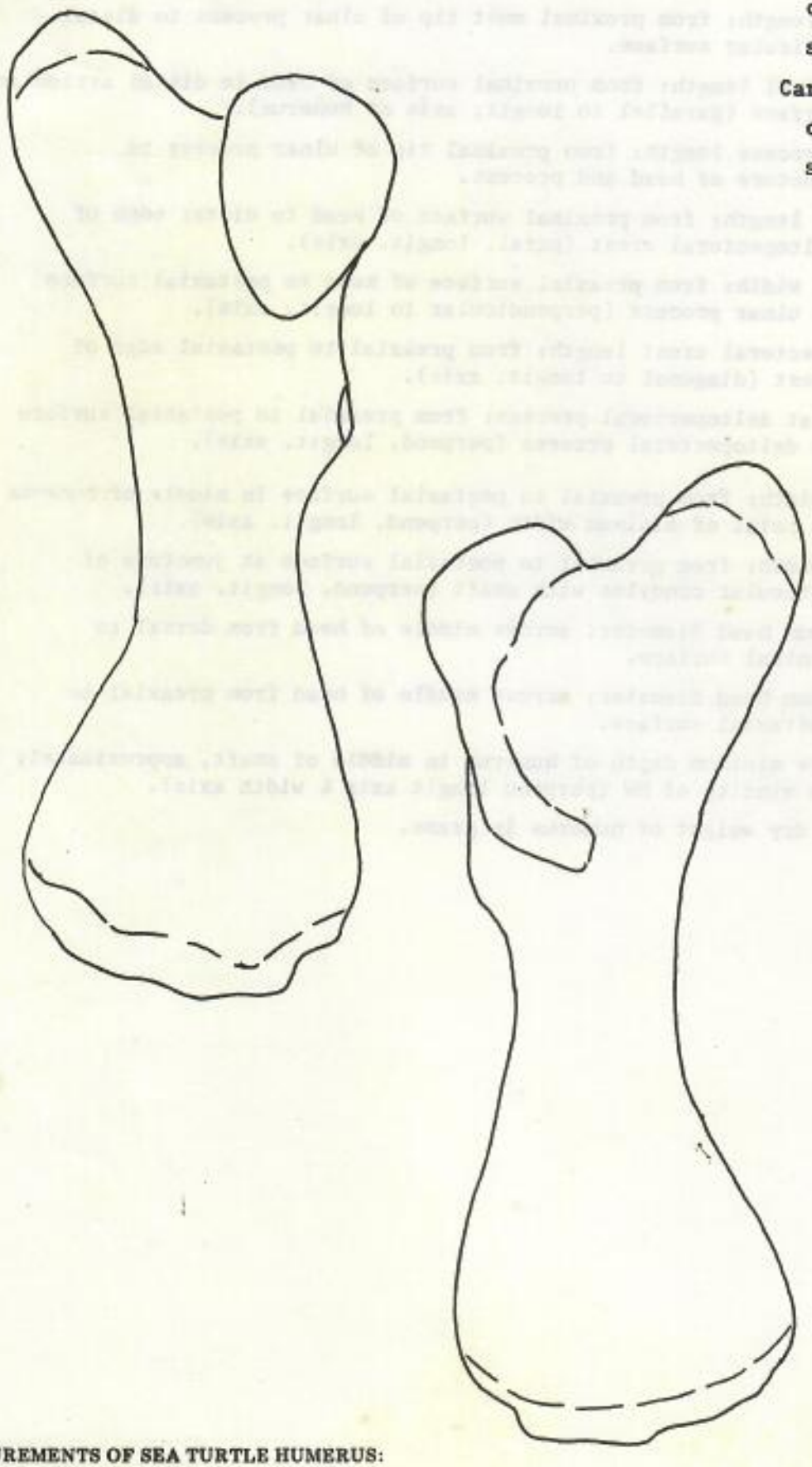
National Museum of Natural History

Species C. mydas Museum # LISIANSKI 9-78 (LEFT) Sex

Carapace length
curve
straight
Carapace width
curve
straight



ML	20.3
LL	18.5
UPL	18.2
PL	
PW	
DPCL	
DPPW	
MW	
DW	
MaxHD	
MinHD	
T	
Wt	223.0

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
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Species C. mydas Museum # KAALUACU 5-77 (LEFT) Sex ____

Carapace length

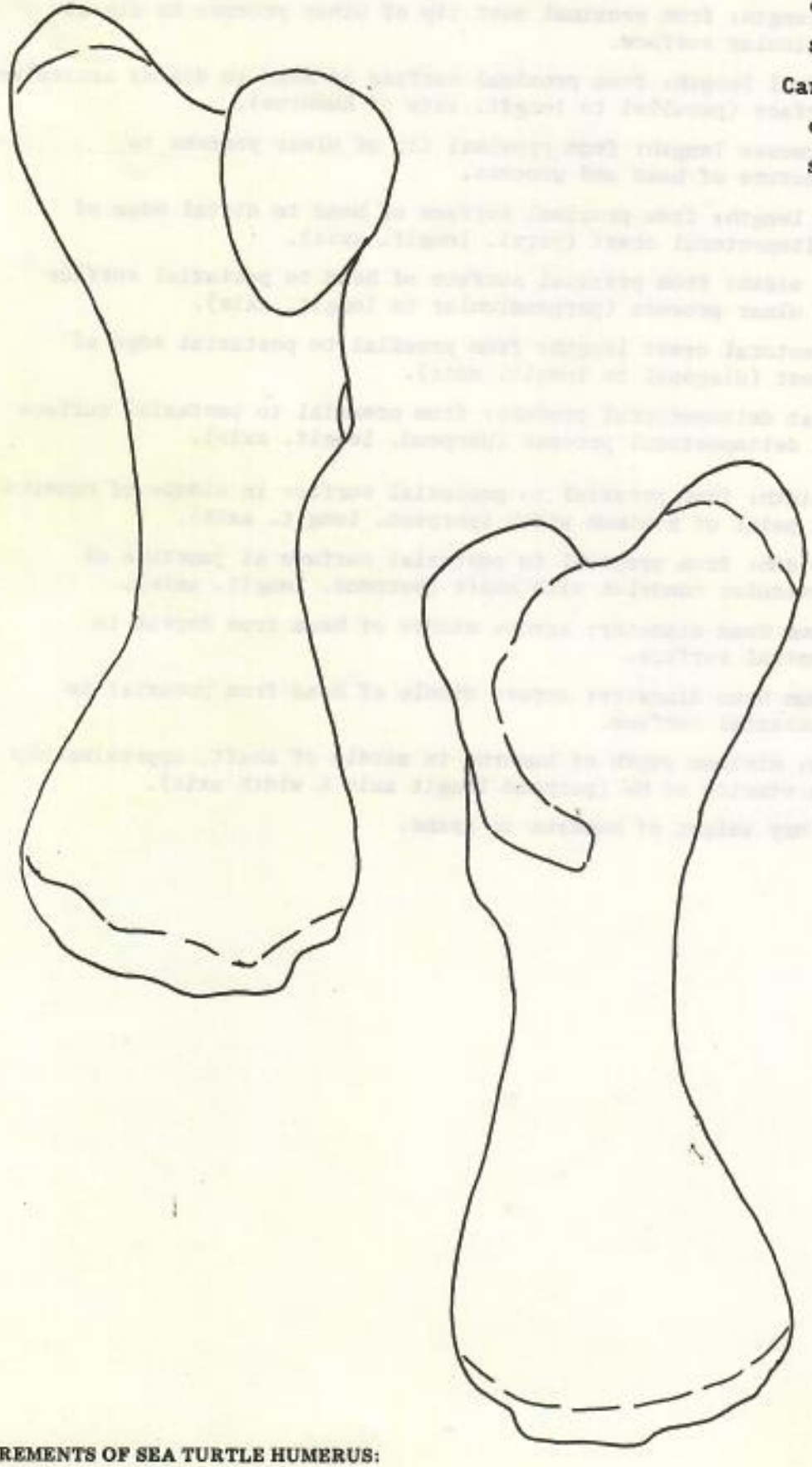
curve ____

straight UNKNOWN

Carapace width

curve ____

straight ____



ML	19.7
LL	18.0
UPL	18.2
PL	
PW	
DPCL	
DPPW	
MW	
DW	
MaxHD	
MinHD	
T	
Wt	145.2

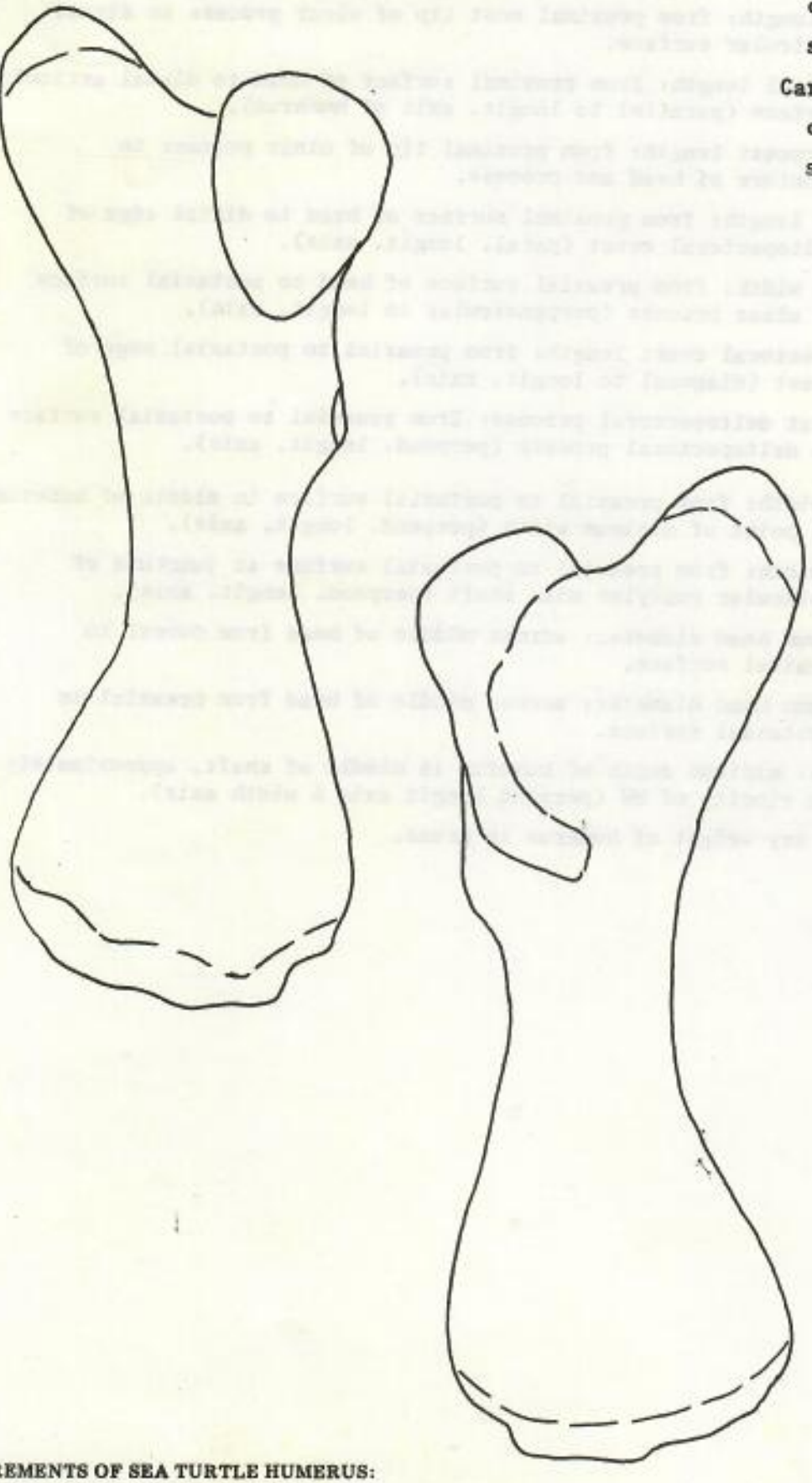
MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
National Museum of Natural History

Species C. mydas Museum # FFS 6-80 (LEFT) Sex M

Carapace length
curve
straight
Carapace width
curve
straight

ML 19.4
LL 18.0
UPL 17.5
PL
PW
DPCL
DPPW
MW
DW
MaxHD
MinHD
T
Wt 203.0



MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
National Museum of Natural History

BARBER'S POINT

Species C. mydas Museum # 4-29-85 Sex F

(RIGHT)

Carapace length

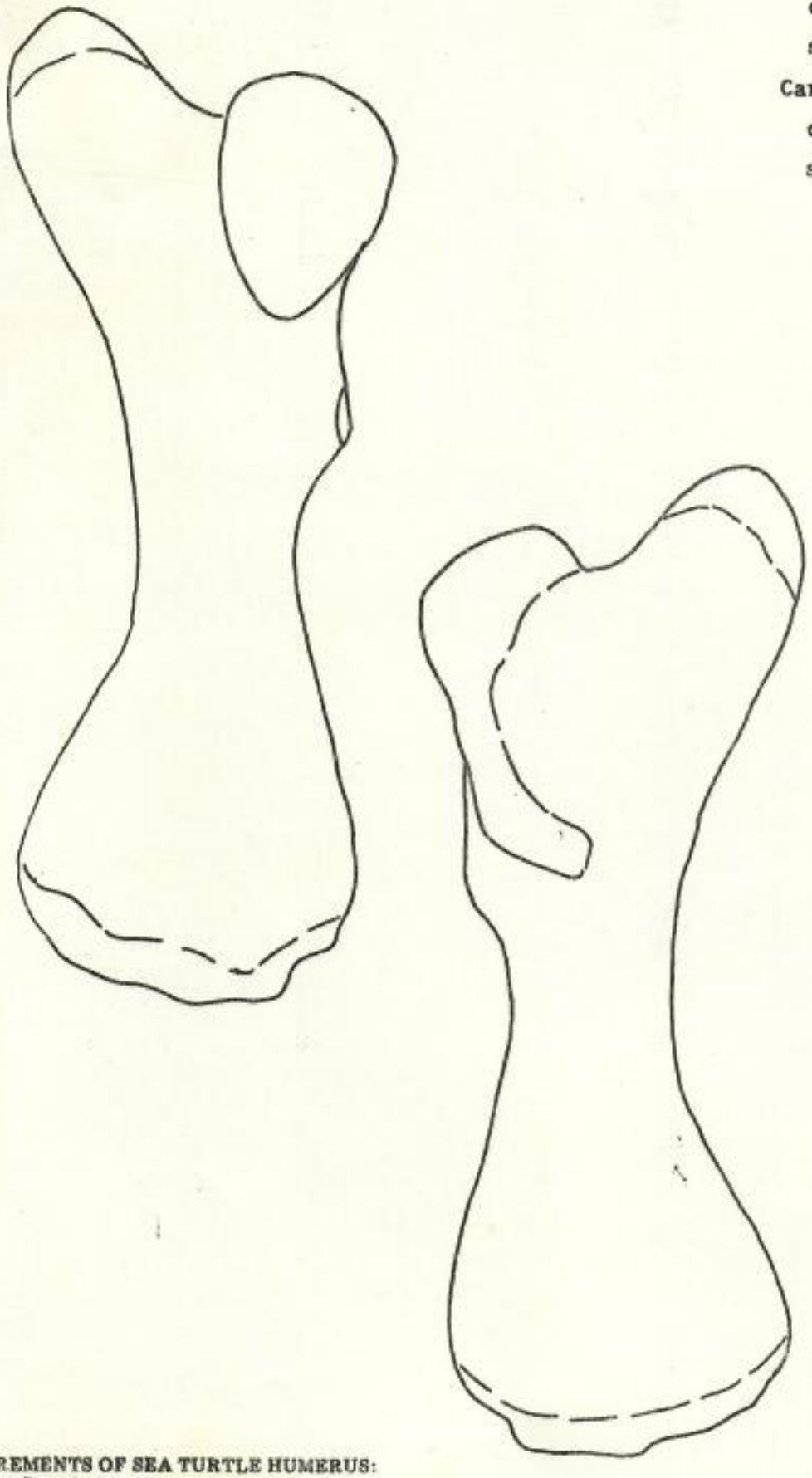
curve _____

straight _____

Carapace width

curve _____

straight _____



ML	203
LL	196
UPL	188
PL	
PW	
DPCL	
DPPW	
MW	
DW	
MaxHD	
MinHD	
T	
Wt	313

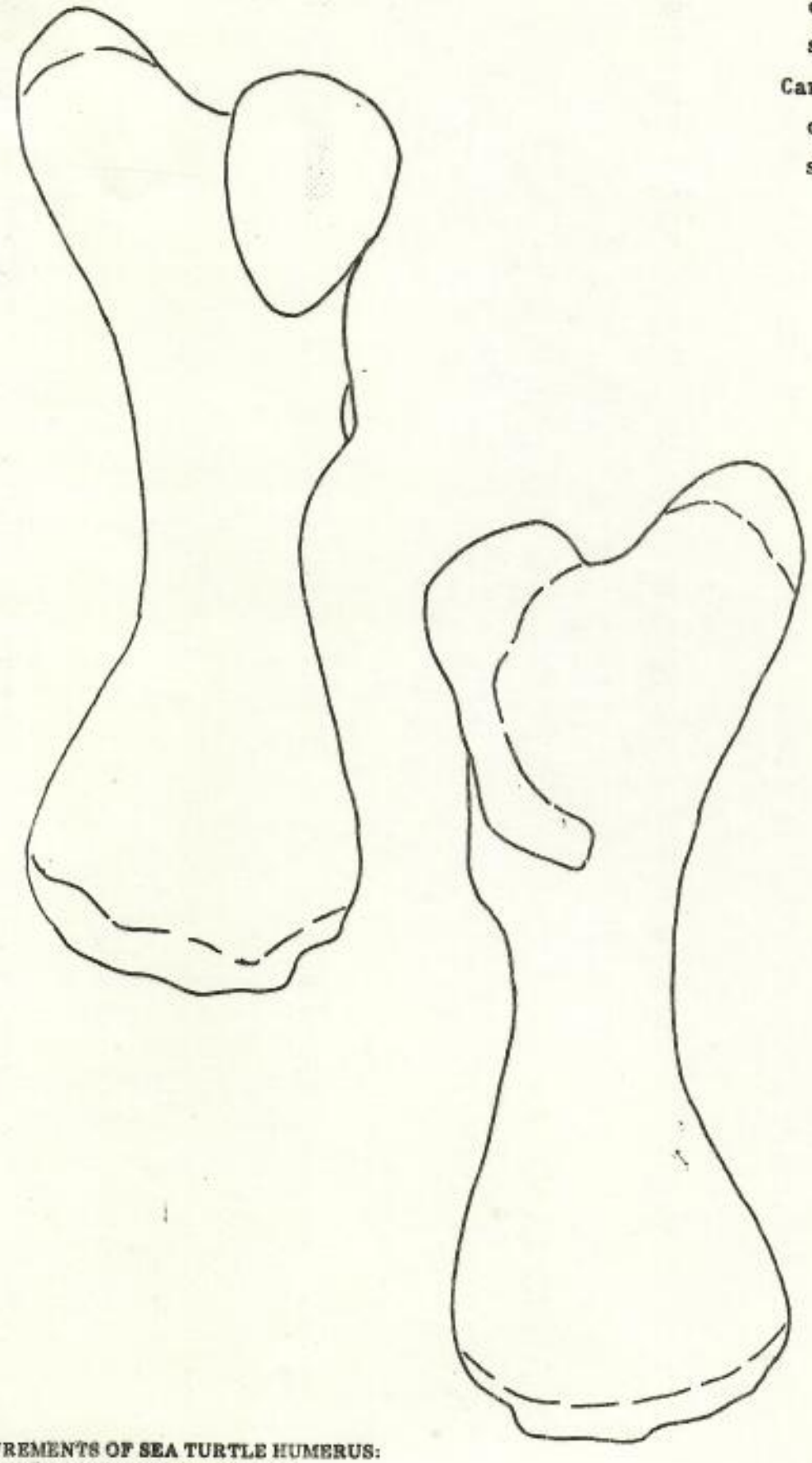
MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
National Museum of Natural History

Species C. mydas Museum # KAILUA #1 (RIGHT) Sex

KAILUA 1

Carapace length
curve
straight
Carapace width
curve
straight



ML 80
LL 74
UPL 73
PL
PW
DPCL
DPPW
MW
DW
MaxHD
MinHD
T
Wt 19.0

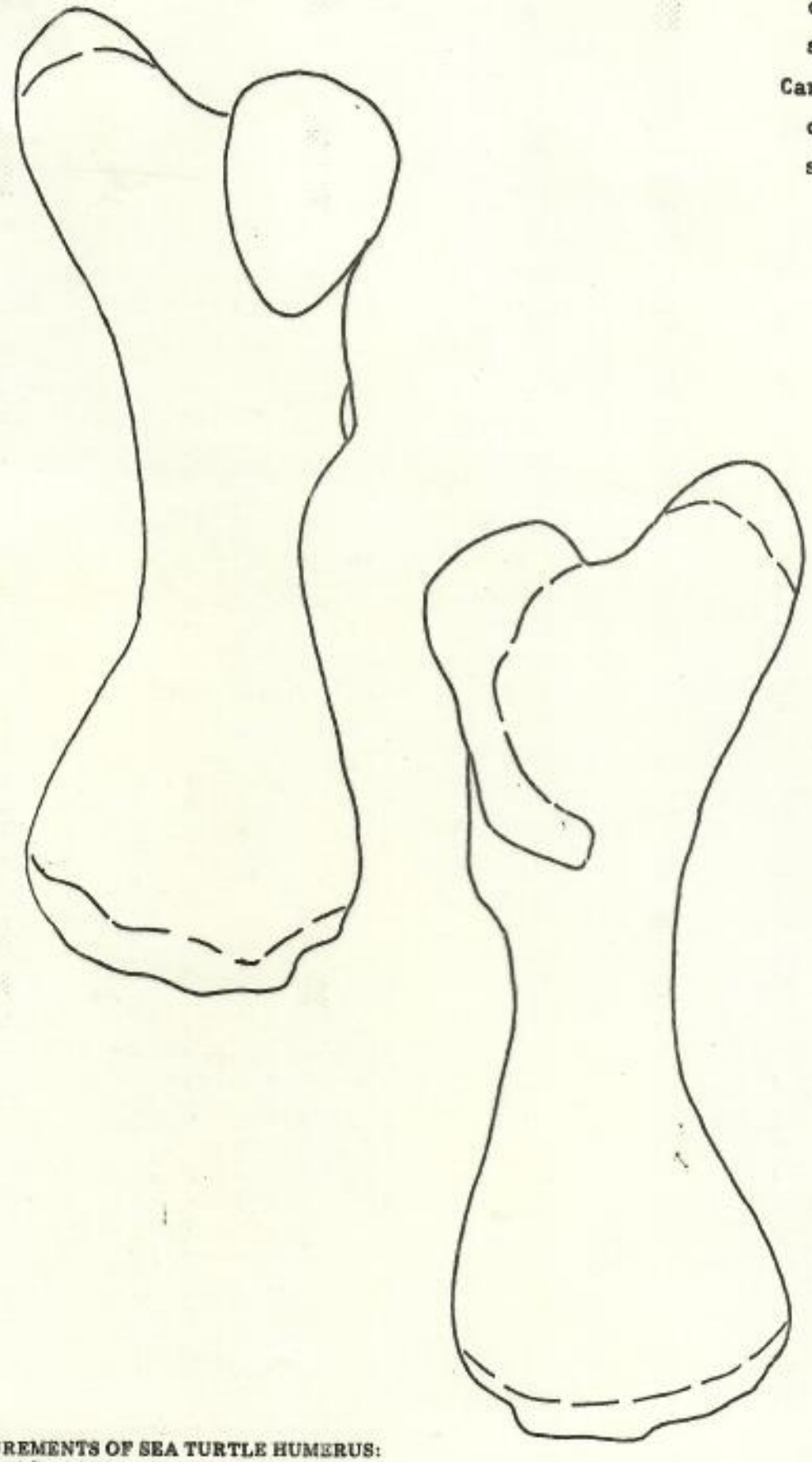
MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
National Museum of Natural History

KAILUA #2

Species C. mydas Museum # _____ Sex _____

(RIGHT)



Carapace length

curve _____

straight _____

Carapace width

curve _____

straight _____

ML 77

LL 74

UPL _____

PL 71

PW _____

DPCL _____

DPPW _____

MW _____

DW _____

MaxHD _____

MinHD _____

T _____

Wt 18.3

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
National Museum of Natural History

20 TOTAL (18 R 2 L)

Species _____ Museum # _____ Sex _____

Carapace length

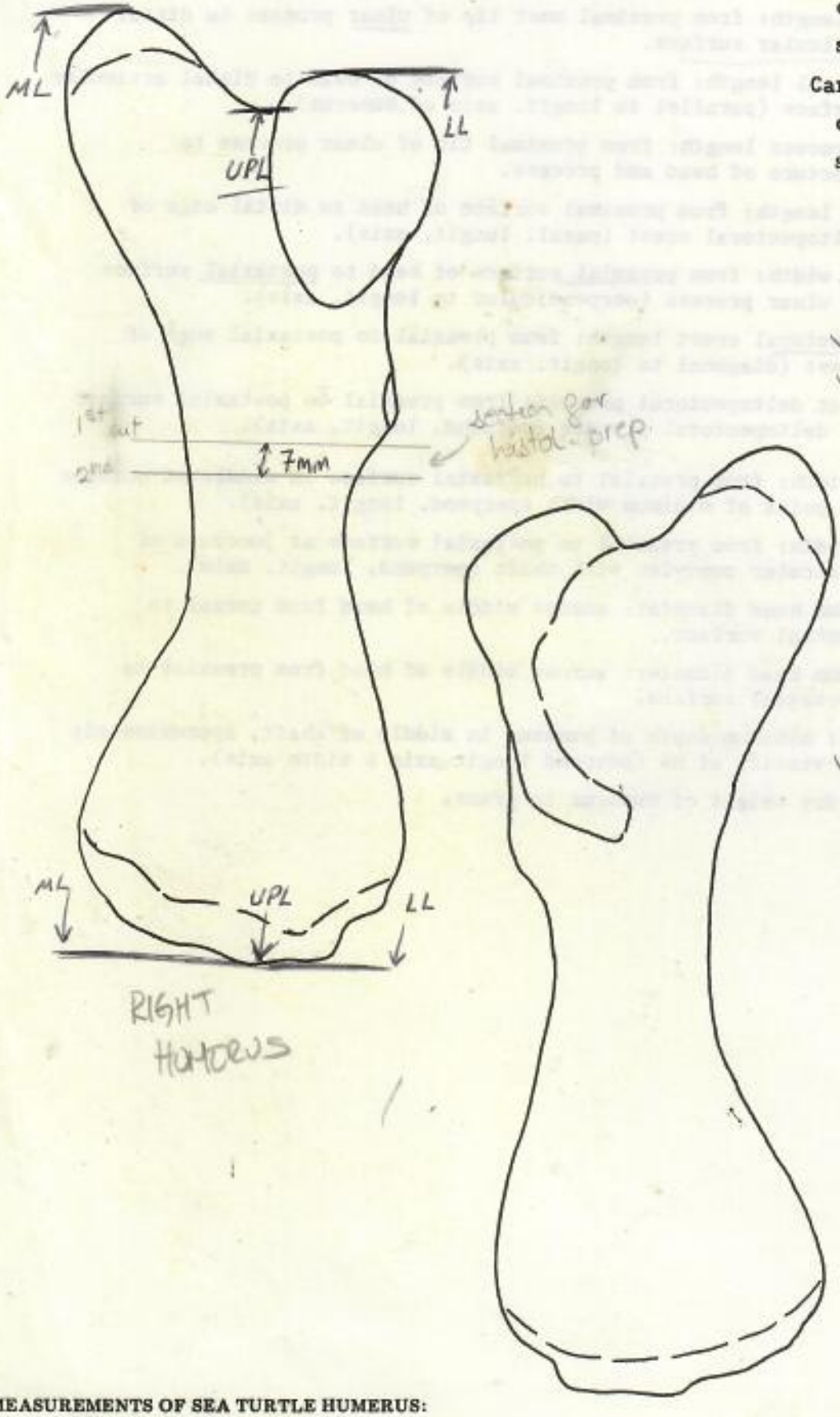
curve _____

straight _____

Carapace width

curve _____

straight _____



RIGHT HUMERUS

ML _____

LL _____

UPL _____

PL _____

PW _____

DPCL _____

DPPW _____

MW _____

DW _____

MaxHD _____

MinHD _____

T _____

Wt _____

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
National Museum of Natural History

National Museum of Natural History · Smithsonian Institution
WASHINGTON, D.C. 20560 · TEL. 202-

- Send Hatchling bone?
- photos above desk

February 20, 1985

Dr. George Balazs
U. S. Department of Commerce
National Oceanic and Atmospheric
Administration
National Marine Fisheries Service F/SWC2
P. O. Box 3830
Honolulu, Hawaii 96812

Dear George:

Rotten sea turtles do stink! We have dug up buried ones months later and have also discovered that they don't rot as fast as you think. Just think of Carol salvaging over 400 Caretta for our aging project. She macerated the right fore flipper and head in her backyard - no neighbors close by. For two years, she had a constant circle of buzzards over her house.

Yes, you can talk me into preparing and examining a dozen or so Chelonia humeri, BUT only if I can get you to send me the 5-7mm slices from the middle of the diaphysis. We used a band saw in the vert paleo and the bones cut easily although care is required to obtain flat sections. I have enclosed data sheets if you wish to measure the bones before halfing them; also one sheet shows position of the section.

I don't recommend cleaning any bones in chlorox. No matter how well they are rinsed, a chlorox residue remains and bone deterioration continues. Chlorox may be a factor in the absence of LAGs, altho Carol only macerated the bones in water and some still were homogeneous. Similarly we have homogeneous toe bones in the Iguanas and there the toes were removed and immediately preserved in formalin. It is strange.

Cordially,

George

George R. Zug
Curator
Division of Amphibians
and Reptiles

Enclosure

Species Chelonia mydas Balazs Museum # 19750 Sex ____

Carapace length

curve ____

straight ____

Carapace width

curve ____

straight ____

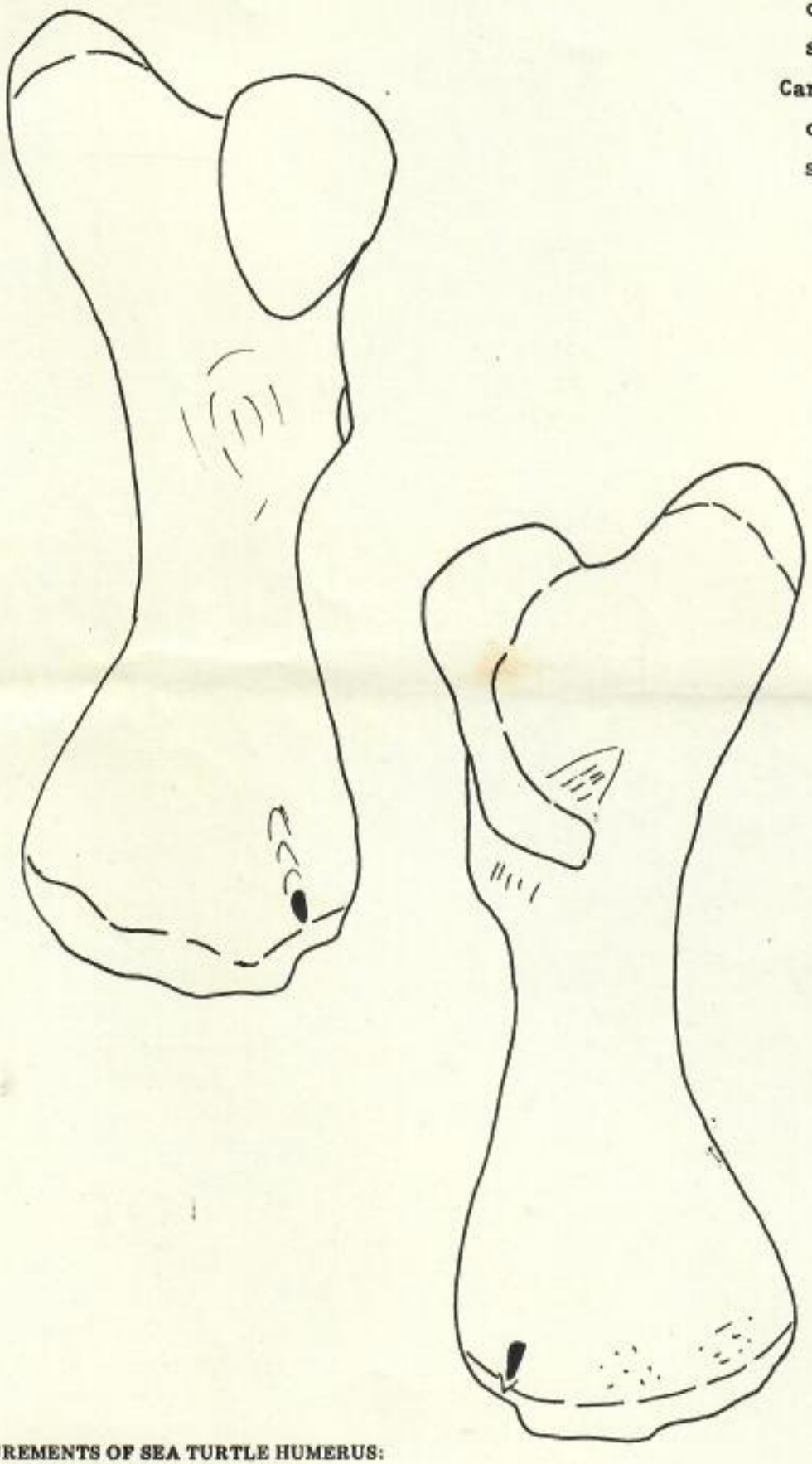
ML	181
LL	192
UPL	38.4
PL	74.0
PW	76.6
DPCL	36.9
DPPW	50.8
MW	37.1
DW	61.4
MaxHD	53.7
MinHD	38.9
T	19.0
Wt	158.7

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
National Museum of Natural History

Species Chelonia mydas Museum # 379BE Sex ____

Carapace length
curve ____
straight ____
Carapace width
curve ____
straight ____



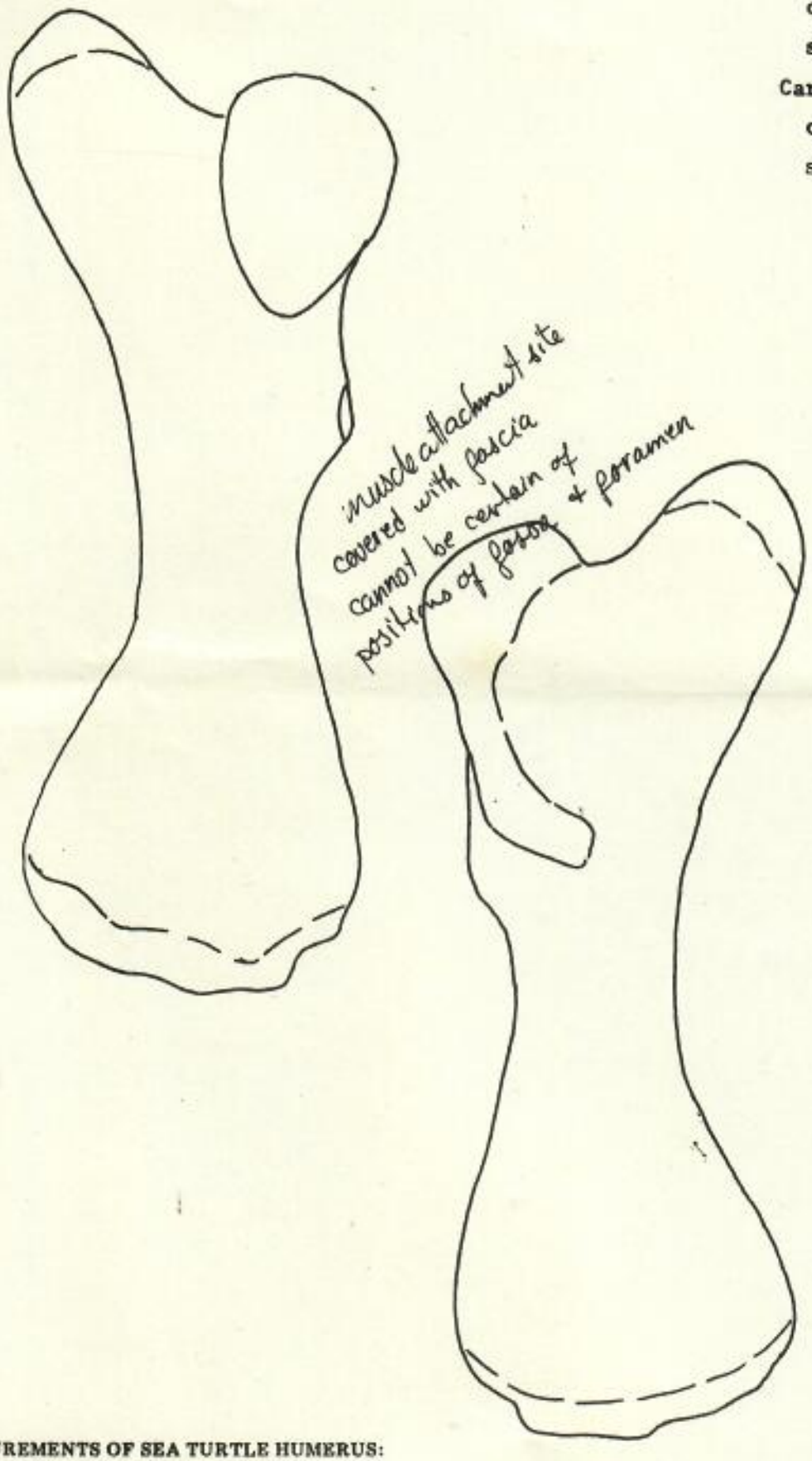
ML	193
LL	179
UPL	41.2
PL	69.4
PW	84.7
DPCL	42.0
DPPW	53.0
MW	34.9
DW	66.8
MaxHD	50.0
MinHD	39.3
T	17.4
Wt	185.1 g (carta fats)

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
National Museum of Natural History

Species Chel. mydas Museum # 777 BE Sex

Carapace length
curve
straight
Carapace width
curve
straight



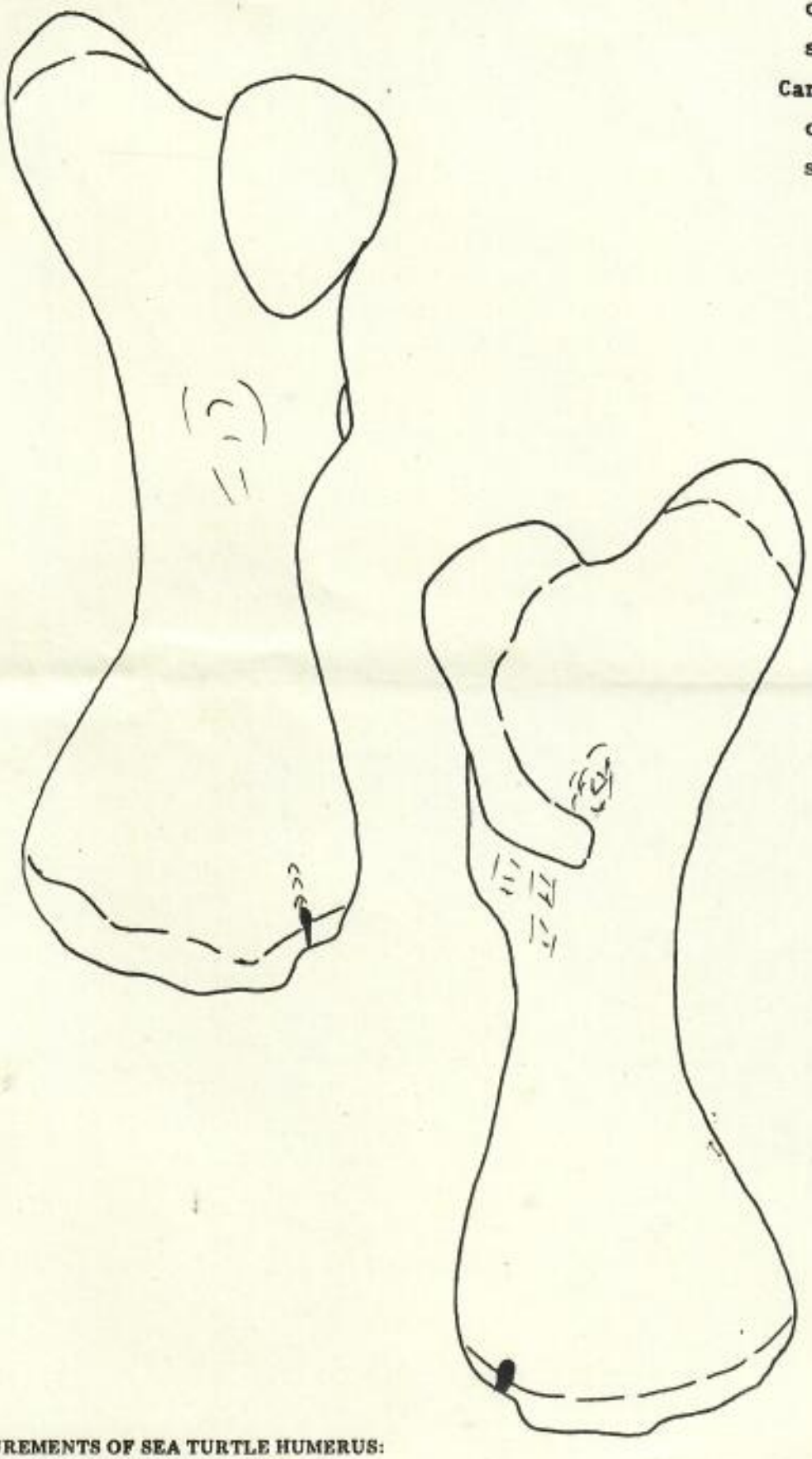
ML	113.9 mm
LL	107.4
UPL	20.8
PL	47.6
PW	47.2
DPCL	22.5
DPPW	36.4
MW	22.7
DW	37.1
MaxHD	30.1
MinHD	23.9
T	11.3
Wt	46.6 g

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
National Museum of Natural History

Species Chelonia mydas Museum # 79 BP Sex

Carapace length
curve
straight
Carapace width
curve
straight



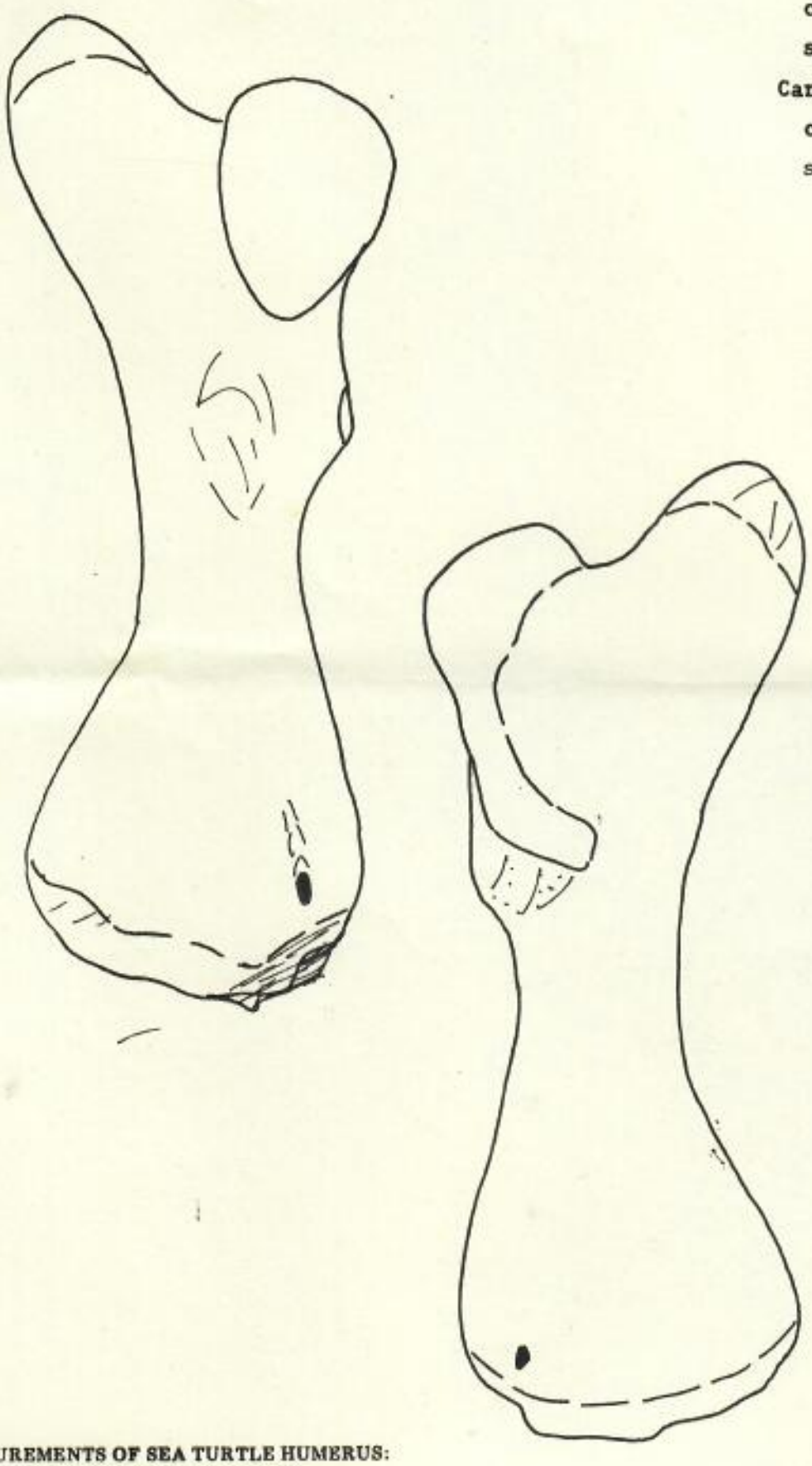
ML	156.5 mm
LL	148.4
UPL	28.7
PL	~~64.2~~ 69.9
PW	~~43.9~~ 64.2
DPCL	30.1
DPPW	43.9
MW	31.4
DW	51.5
MaxHD	42.4
MinHD	32.8
T	15.6
Wt	106.2g

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
National Museum of Natural History

Species Chelonia mydas Museum # 83 KB Sex ____

Carapace length
curve ____
straight ____
Carapace width
curve ____
straight ____



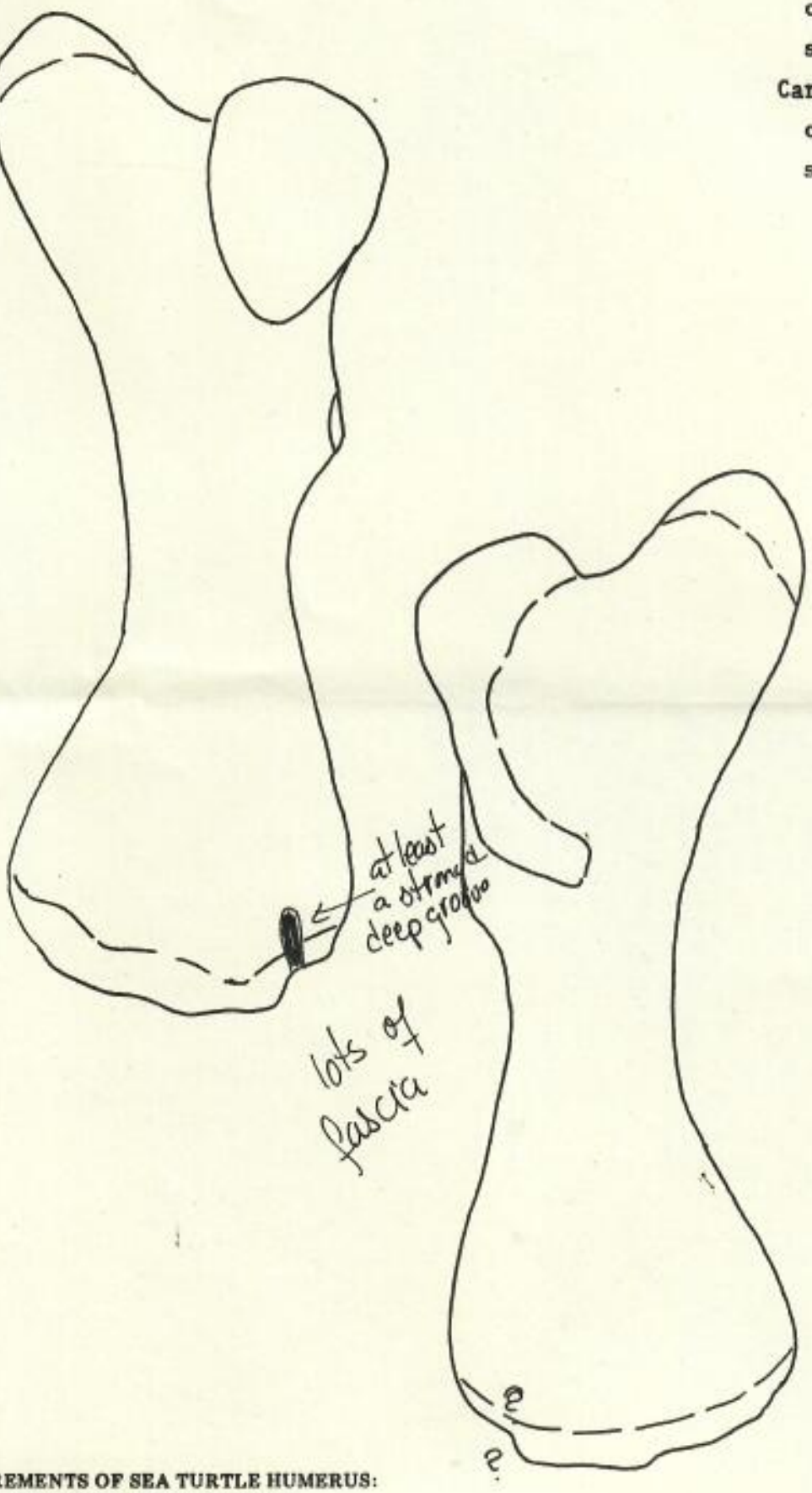
ML	194 mm
LL	185
UPL	47.1
PL	91.2
PW	87.1
DPCL	39.8
DPPW	51.5
MW	39.2
DW	69.7
MaxHD	60.5
MinHD	43.5
T	20.9
Wt	295g notched

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
National Museum of Natural History

Species Ch. mydas Museum # 677 FF Sex

Carapace length
curve
straight
Carapace width
curve
straight



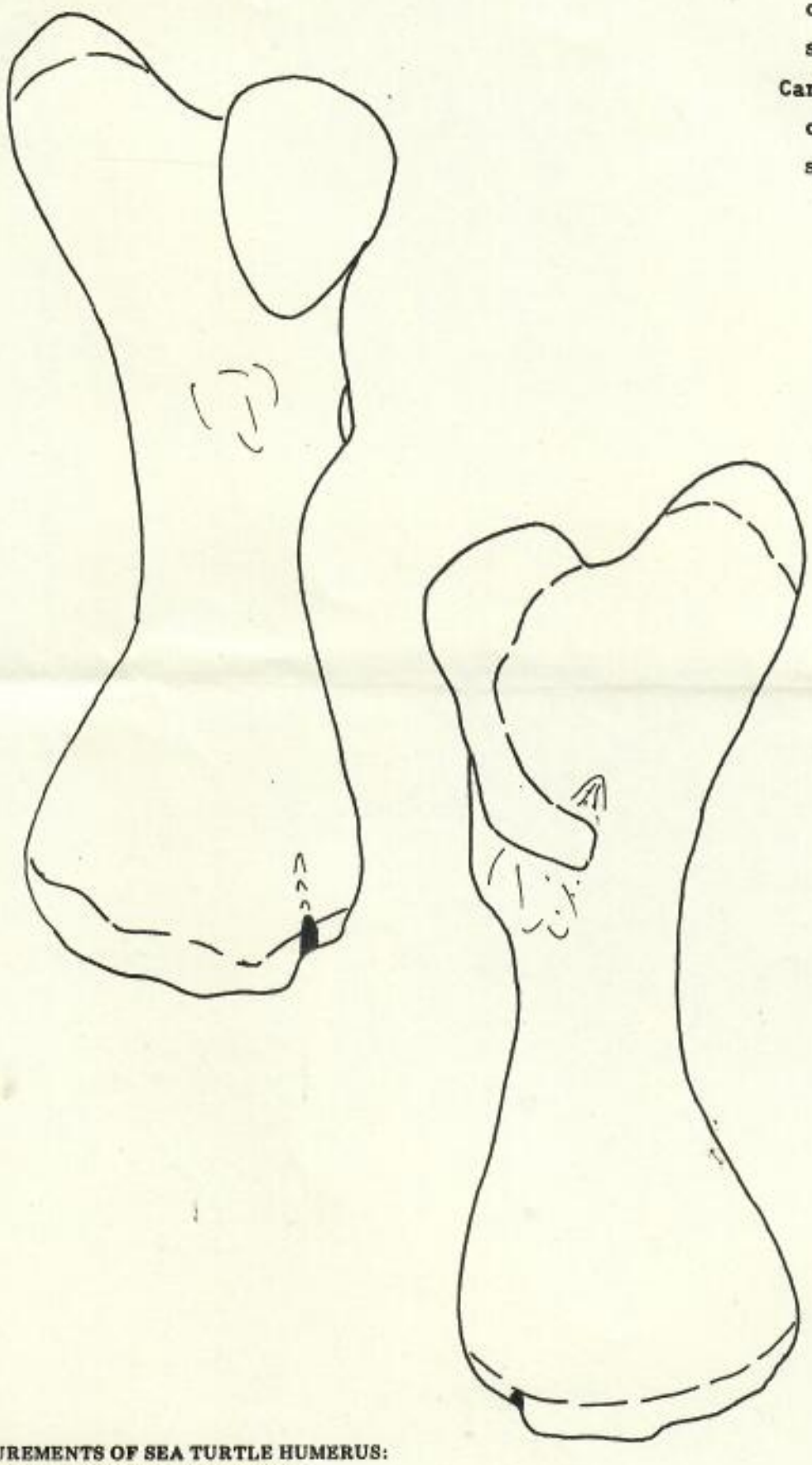
ML	82.9
LL	75.5
UPL	14.2
PL	36.1
PW	37.3
DPCL	15.2
DPPW	28.7
MW	18.1
DW	29.9
MaxHD	23.9
MinHD	18.1
T	8.4
Wt	23.3g

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
National Museum of Natural History

Species Ch. mydas Museum # 5630 Sex

Carapace length
curve
straight
Carapace width
curve
straight



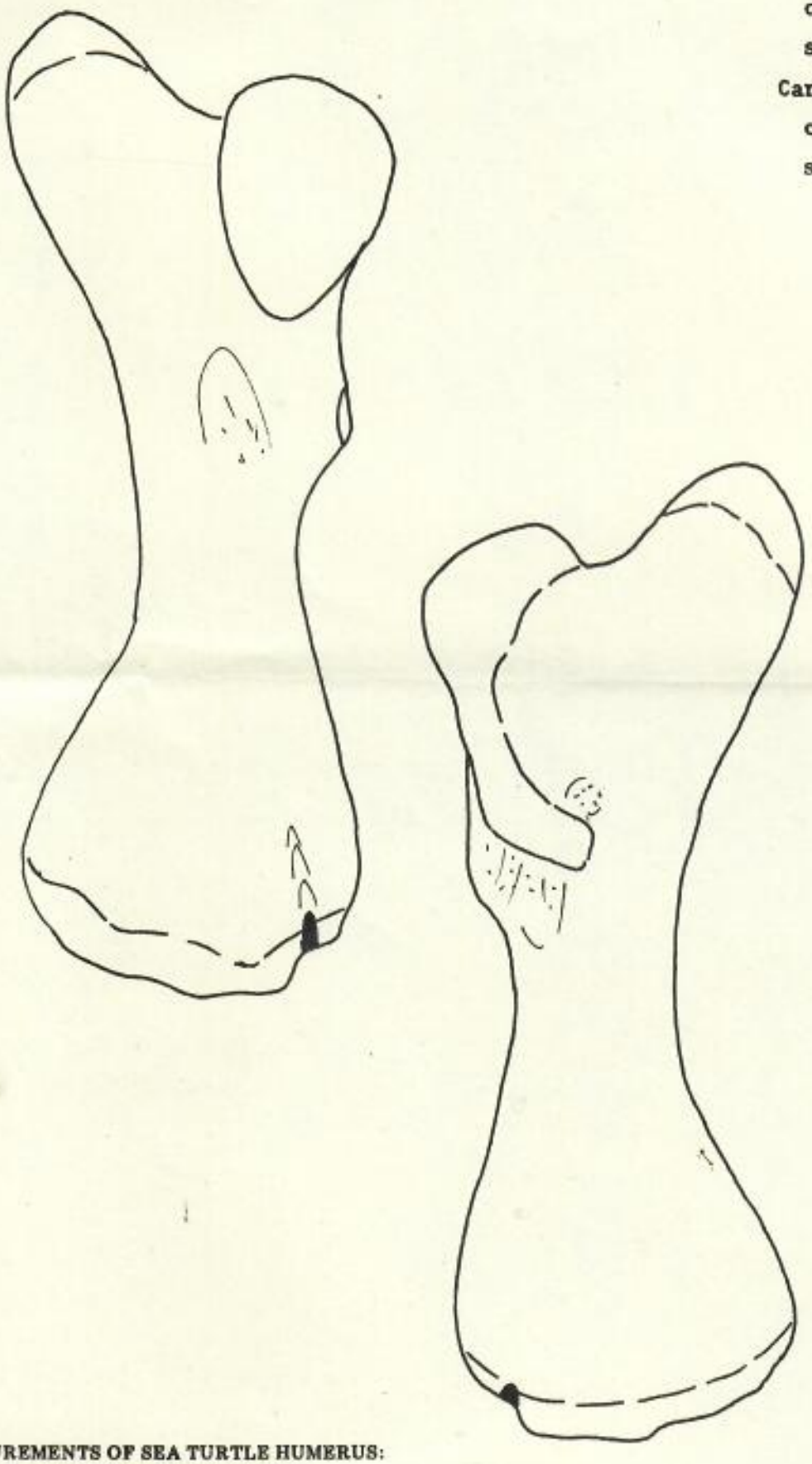
ML	63.3 mm
LL	61.3
UPL	11.6
PL	28.9
PW	30.6
DPCL	13.6
DPPW	21.2
MW	14.1
DW	26.4
MaxHD	21.3
MinHD	16.2
T	6.9
Wt	10.3 g

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
National Museum of Natural History

Species Ch. mydas Museum # 78 KU1 Sex

Carapace length
curve
straight
Carapace width
curve
straight



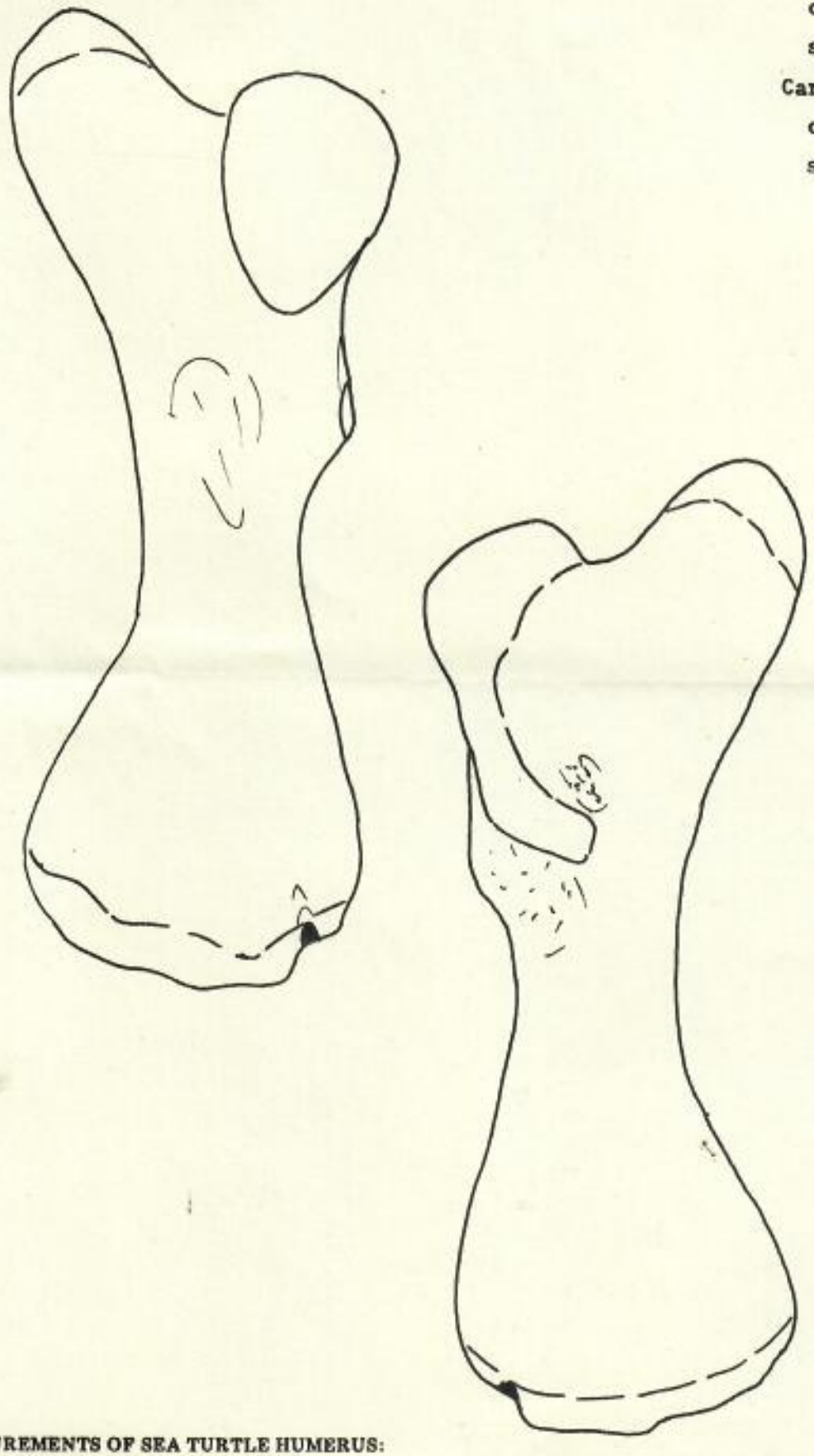
ML	79.6 mm
LL	74.5
UPL	13.2
PL	33.3
PW	32.9
DPCL	16.7
DPPW	22.9
MW	15.9
DW	19.2
MaxHD	24.5
MinHD	17.2
T	7.8
Wt	17.8 g

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
National Museum of Natural History

Species Ch. mydas Museum # 78KU2 Sex

Carapace length
curve
straight
Carapace width
curve
straight



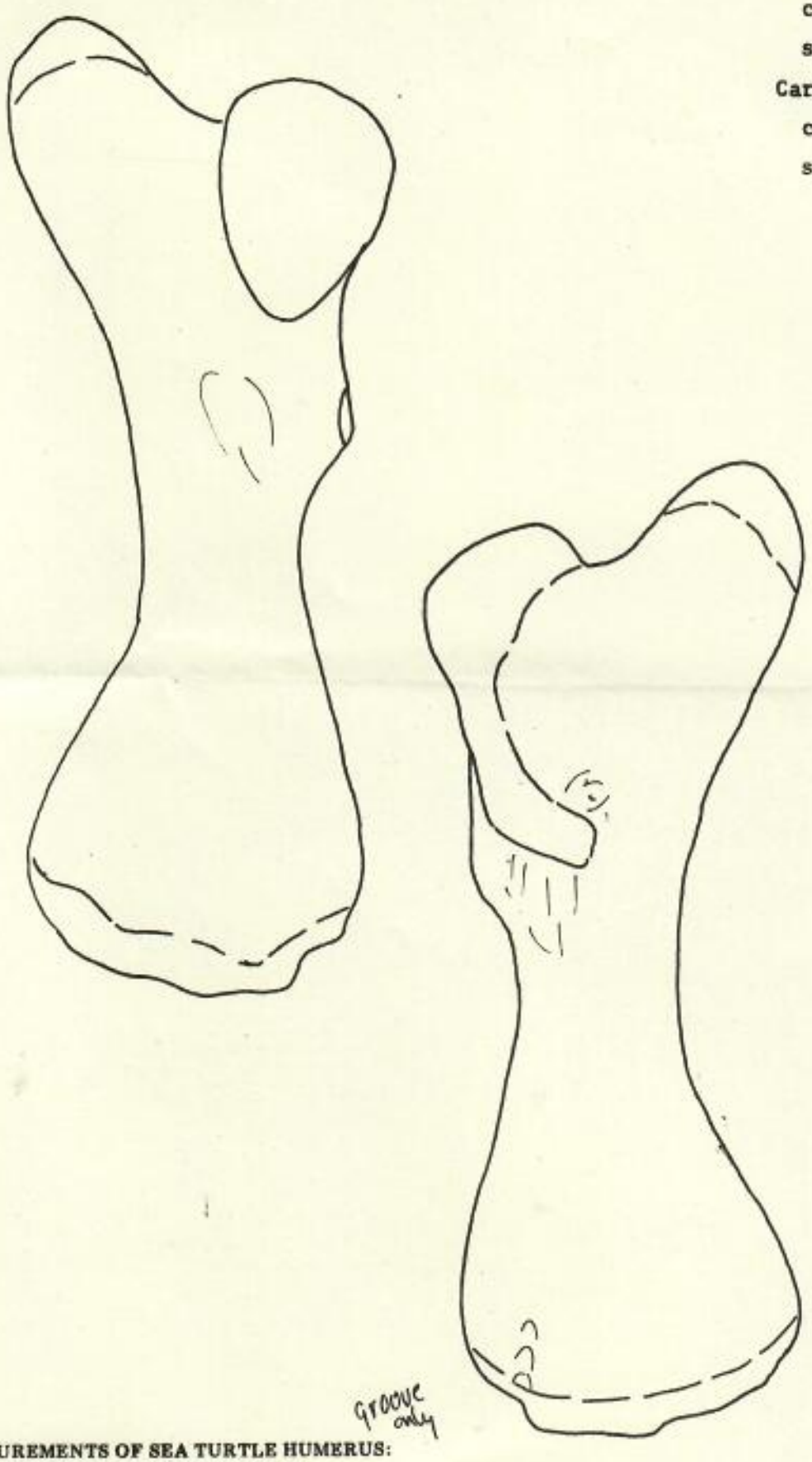
ML	111.0 mm
LL	104.7
UPL	18.4
PL	42.4
PW	46.4
DPCL	22.4
DPPW	32.4
MW	21.5
DW	~~10.6~~ 38.6
MaxHD	30.7
MinHD	25.3
T	~~3~~ 10.8
Wt	40.0 g

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
National Museum of Natural History

Species Ch. mydas Museum # FGB Sex

Carapace length
curve
straight
Carapace width
curve
straight



ML	86.7 mm
LL	82.7
UPL	16.4
PL	36.4
PW	37.6
DPCL	17.5
DPPW	26.5
MW	18.7
DW	33.0
MaxHD	24.7
MinHD	19.0
T	9.0
Wt	24.8 g

? Likely a rapidly growing individual

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
National Museum of Natural History

Species Chelonia mydas Museum # 677 Canton Sex ____

Carapace length
curve ____
straight ____
Carapace width
curve ____
straight ____

ML	202 mm
LL	± 192
UPL	38.0
PL	72.8
PW	82.8
DPCL	38.4
DPPW	61.1
MW	41.4
DW	68.3
MaxHD	57.9
MinHD	43.8
T	20.1
Wt	284 g

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
National Museum of Natural History

51-7A
Rev. 2-70

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Washington, D.C., U.S.A. 20560

A LETTER HAS, HAS NOT, BEEN WRITTEN

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INITIATING OFFICE INVOICE NO.

DATE 13 March 1984

TO:
National Marine Fisheries Service
P. O. Box 3830
Honolulu, Hawaii 96812

ATTENTION: George Balazs

LOAN PERIOD

INITIATED BY Ken A. Tighe

UNIT Amphibians & Reptiles

APPROVED George R. Zug

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(7)

(5)

MATERIAL (*As appropriate, state locality, collector, catalog numbers, etc. Total each distribution category*)

Hawaiian Green Turtles

Right humerus (photocopies of data sheets enclosed

Specimen number	
1975 W	1
83 KB	1
379 BE	1
79 BP	1
777 BE	1
78 KU2	1
FGB	1
677 FF	1
78KU1	1
5630	1
677 Canton	1

Total: 11 specimens

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Species_____ Museum #_____ Sex_____

Carapace length

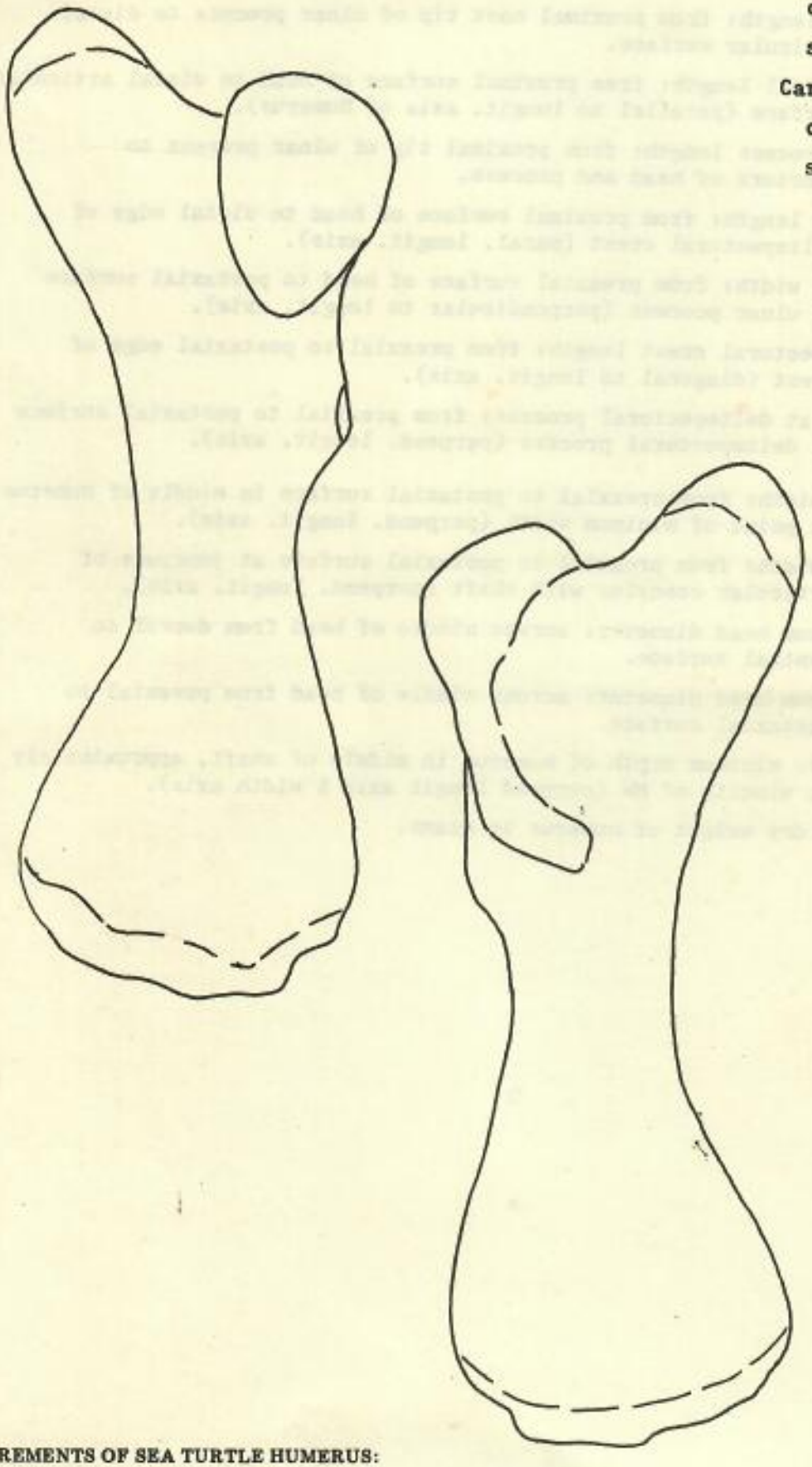
curve _____

straight _____

Carapace width

curve _____

straight _____



ML _____

LL _____

UPL _____

PL _____

PW _____

DPCL _____

DPPW _____

MW _____

DW _____

MaxHD _____

MinHD _____

T _____

Wt _____

MEASUREMENTS OF SEA TURTLE HUMERUS:
All Straight Line Distances in MM.

SI-848 9-16-80
Reptiles/Amphibians
Dept of Vertebrate Zoology
National Museum of Natural History

REMINDER SENT 1-15-86

National Museum of Natural History · Smithsonian Institution
WASHINGTON, D.C. 20560 • TEL. 202-

November 25, 1985

Dr. George Balazs
U. S. Dept. of Commerce, NOAA
National Marine Fisheries Service
D/swc2
P. O. Box 3830
Honolulu, Hawaii 96812

Dear George:

I do need the reminding. The histological slides have been sitting by the microscope for several months. My excuse is that I have been away from the museum more than I have been here since July. That excuse will not be applicable for the next several months, so I should be able to count growth marks. If you don't hear from me by the end of the year, give me a hard prod in January.

The aging studies have intrigued a fair number of people. Ruth Ellen Klinger is a grad student at UIMS and attempting to age some of the Chesapeake Caretta with our technique. She has also injected tetracycline into some specimens and was able to obtain a few of these specimens in her stranding samples. The results, however, remain unknown, at least when I talked with her in July.

Cordially,

George

(George R.) Zug
Curator
Division of Amphibians
and Reptiles

National Museum of Natural History · Smithsonian Institution
WASHINGTON, D.C. 20560 • TEL. 202-

21 May 85

Dear George:

sent 6-10-85 3 hatchlings

Received the additional three pieces of bone today. No more, please. I am trying to get out of the skeletochronology business and the Hawaiian greens is the last project.

The simplest way to send the hatchling is to preserve them in standard 4% formalin. We have to fix the bone prior to decalcification, so preservation will save us that step. Thaw before injecting the formalin. Two specimens should do.

Regards,
George

Herpetologica, 41(2), 1985, 228–234

TETRACYCLINE AS AN IN VIVO LABEL IN BONES OF GREEN TURTLES, *CHELONIA MYDAS* (L.)

J. FRAZIER

ABSTRACT: Oxytetracycline when injected intramuscularly produces fluorochrome in bones of the sea-turtle *Chelonia mydas* (L.). Dosages of from 5–28 mg/kg body weight produced in vivo labels, with no apparent effects on the experimental animals. Brightness of the fluorescence varied with dosage. The label was incorporated rapidly and lasted for 3 yr in the sample. The results are comparable to those from studies performed on mammals, and proffer a useful technique for measuring accretion of hard tissue in herpetological studies—especially for age determination and growth.

Key words: Age determination; Chelonia; Growth; In vivo label; Tetracycline

IN VIVO labels provide unique opportunities to study physiological processes. When applied to hard tissues, these labels are invaluable in studies of growth and age determination. Although techniques for incorporating in vivo labels are well studied in fishes and mammals, there have been few herpetological investigations, and all of these have been on either European or Asian animals. Most of the herpetological studies have used labels without investigating potential side effects, and many have not reported details of the technique (see review in Frazier, 1985). The present study investigates the feasibility of labeling bones of green turtles, *Chelonia mydas*, with oxytetracycline to measure later rates of bone deposition and interpret growth-related phenomena in these large, long-lived poikilotherms.

MATERIALS AND METHODS

The experimental animals were farm-reared green turtles, *Chelonia mydas*, at the Cayman Turtle Farm (CTF) on Grand Cayman Island, British West Indies (see Ulrich and Parkes, 1978, for a description of the facility). On 7 January 1982, six turtles (tagged 381–386) were 39 (±2) mo of age and weighed between 15 and 31 kg. They were injected with Liquamicin LA-200 (oxytetracycline batch 06136; Pfizer, New York, New York 10017) dorsal to the right hind limb in the area of the flexor tibialis externus with doses that ranged from 4.9–27.9 mg LA-200/kg body weight (Table 1). These six animals were transferred from a 29 m diameter stock tank to a 3 m tank. Samples were taken at three times after treatment. After 29 h, a wedge, about 5 × 15 mm, of marginal scute and peripheral bone was cut from the 10th right marginal of each turtle. Similar wedges were cut from two control animals (CT 54 and CT 56) that came from the same stock tank immediately after they were killed in the normal course of the CTF's activities. No sham (e.g., saline injected) controls were run in an attempt to minimize the interference to the normal running of the farm. On 26 May (139 days after treatment), turtle 384 was found dead, and a humerus, femur and wedge of marginal/peripheral were removed. On 29 September (265 days after treatment), wedges were cut from the remaining five live experimental animals. These samples are referred to as "29-hour" (six specimens), "139-day" (one specimen) and "265-day" (five specimens) samples.

Each wedge was frozen in a plastic vial with a label and was wrapped in aluminum foil or a dark bag until it could be sectioned. Individual wedges were later mounted on paraffin and were sectioned on an Isomet Low Speed Saw (Buehler, Ltd.) cutting 5–13 wafers per wedge. Each wafer was measured with a vernier micrometer at each of the three angles of the triangle, to calculate an average thickness

TABLE 1.—Body weights, dosages and fluorescence scores of *Chelonia mydas* (L.) injected with Liquamycin LA-200.

Specimen number	Date sampled (1982)	Body weight (kg)	LA-200 injected (ml)	Dosage (mg/kg)	Fluorescence score			Grand average
					Dorsal	Ventral	Tip	
CT 54	8 Jan.	15.4	0	0	0.50	0.50	0.33	0.44
CT 56	8 Jan.	25.4	0	0	0.17	0.00	0.67	0.28
381	8 Jan.	24.5	0.6	4.9	0.83	1.67	0.67	1.06
382	8 Jan.	24.9	1.2	9.6	1.67	1.83	1.67	1.72
383	8 Jan.	16.3	1.6	19.6	2.00	3.00	1.67	2.22
384	8 Jan.	19.1	0.5	5.2	0.00	0.50	0.83	0.44
385	8 Jan.	21.8	1.1	10.1	2.00	2.50	2.00	2.17
386	8 Jan.	22.2	3.1	27.9	2.33	3.83	3.33	3.17
381	29 Sept.				1.75	1.88	0.50	1.38
382	29 Sept.				2.80	0.40	1.80	1.67
383	29 Sept.				2.80	2.00	0.00	1.60
384	26 May				0.00	0.00	0.00	0.00
385	29 Sept.				2.75	2.00	2.17	2.31
386	29 Sept.				3.83	2.33	3.58	3.25

for the wafer; they varied from 0.15–1.65 mm in thickness. Sections were replaced in their vials and refrozen until they could be examined.

The wafers, without being fixed, decalcified, stained or permanently mounted, were laid on glass slides and examined under a Leitz Dialux 20 microscope with a Ploemopak mercury light source and H2 filter cube, which excites at a wavelength of 490–500 μm. Photographs were made with a Vario Orthomat camera and Kodak Technical Pan Film 2415.

Each wafer was scanned and scored on the basis of fluorescence from 0–4: no glow, faint glow, definite line, bright line, brilliant line. Dorsal and ventral surfaces as well as the tip (Figs. 1 and 2) were scored separately for each wafer. A series of five or six contiguous wafers for each wedge was chosen, maximizing the possible scores, for those wafers on either end of the wedge were often too thick or had too little bone to be read well. The scores for dorsal, ventral and tip were averaged for each wedge, and these three means yielded a grand mean for each wedge.

All five of the 265-day samples were examined for post-treatment growth. From the distal tip of the peripheral bone, where dorsal and ventral surfaces meet, a distance of 3 mm was traced medially, first along the dorsal surface, then along the ventral surface. At each of these two points for each wafer, the distance between the fluorescent line and the inner edge of keratin was measured. An average for each specimen was calculated for both dorsal and ventral surfaces. These values were then averaged for an overall mean for each specimen.

RESULTS

Areas of yellow-green fluorescence were seen in wafers of both control and experimental turtles, indicating the presence of auto- and/or low-level dispersed fluorescence. This was especially notable in lacunae and keratin (Fig. 1). Diffuse fluorescence was evident in many of the wafers to varying degrees of brightness and did not appear to be dosage-dependent. In the experimental animals, a line of fluorescence was seen at the outer edge of the bone, immediately interior to the periosteum, in an area inferred to have active osteogenesis. Occasionally diffuse- and auto-fluorescence made this line difficult to detect, but at least segments of lines were usually distinct in the treated animals (Fig. 2), and normally they were more golden in color.

In the 29-hour samples, the ventral surface consistently (except in controls)

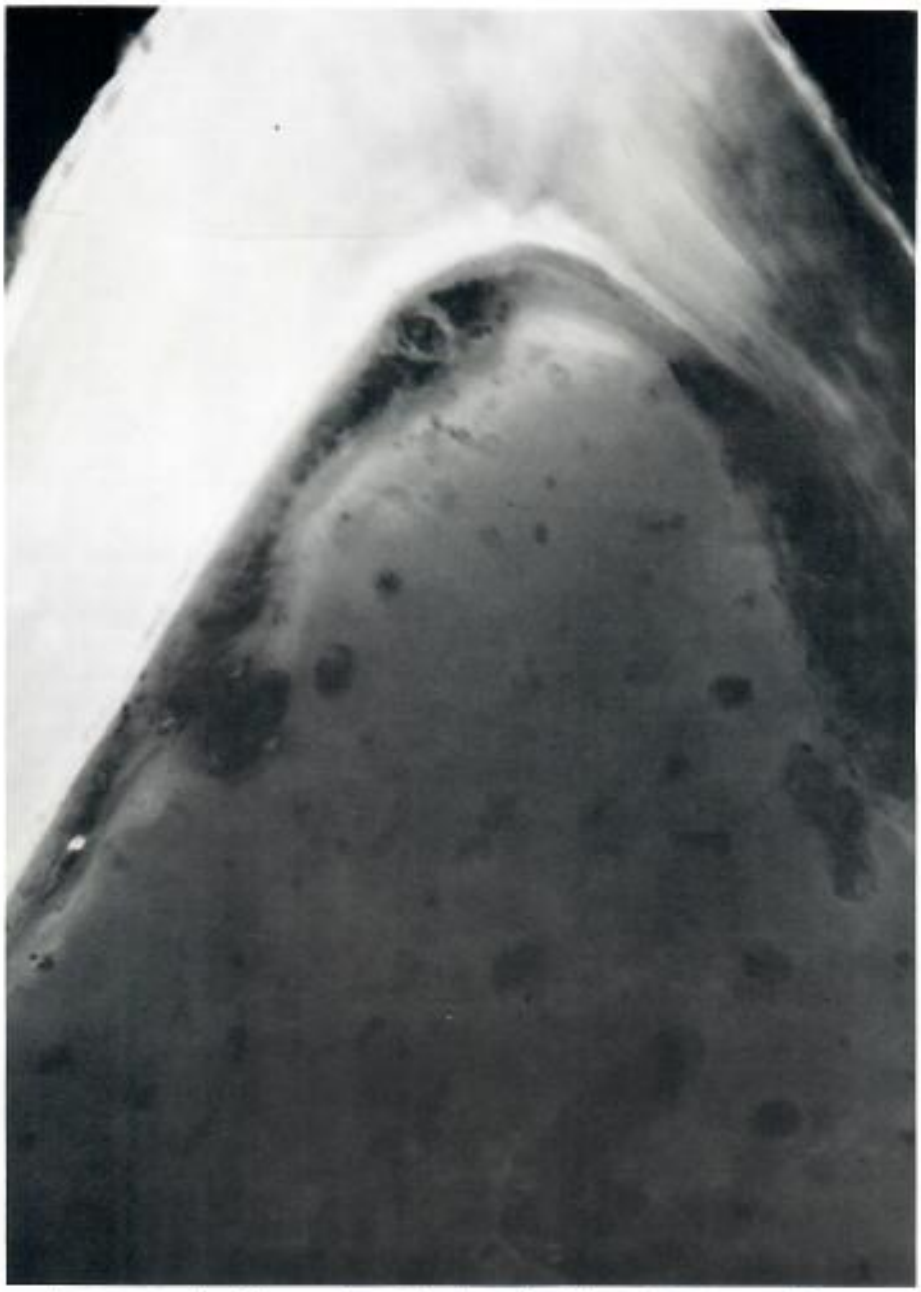


FIG. 1.—Photomicrograph of the tip of a wafer of peripheral bone of a captive *Chelonia mydas* (L.), control No. CT 56; striated band to the left shows bright autofluorescence in the ventral surface of keratin, but there is no fluorescence in the bone.

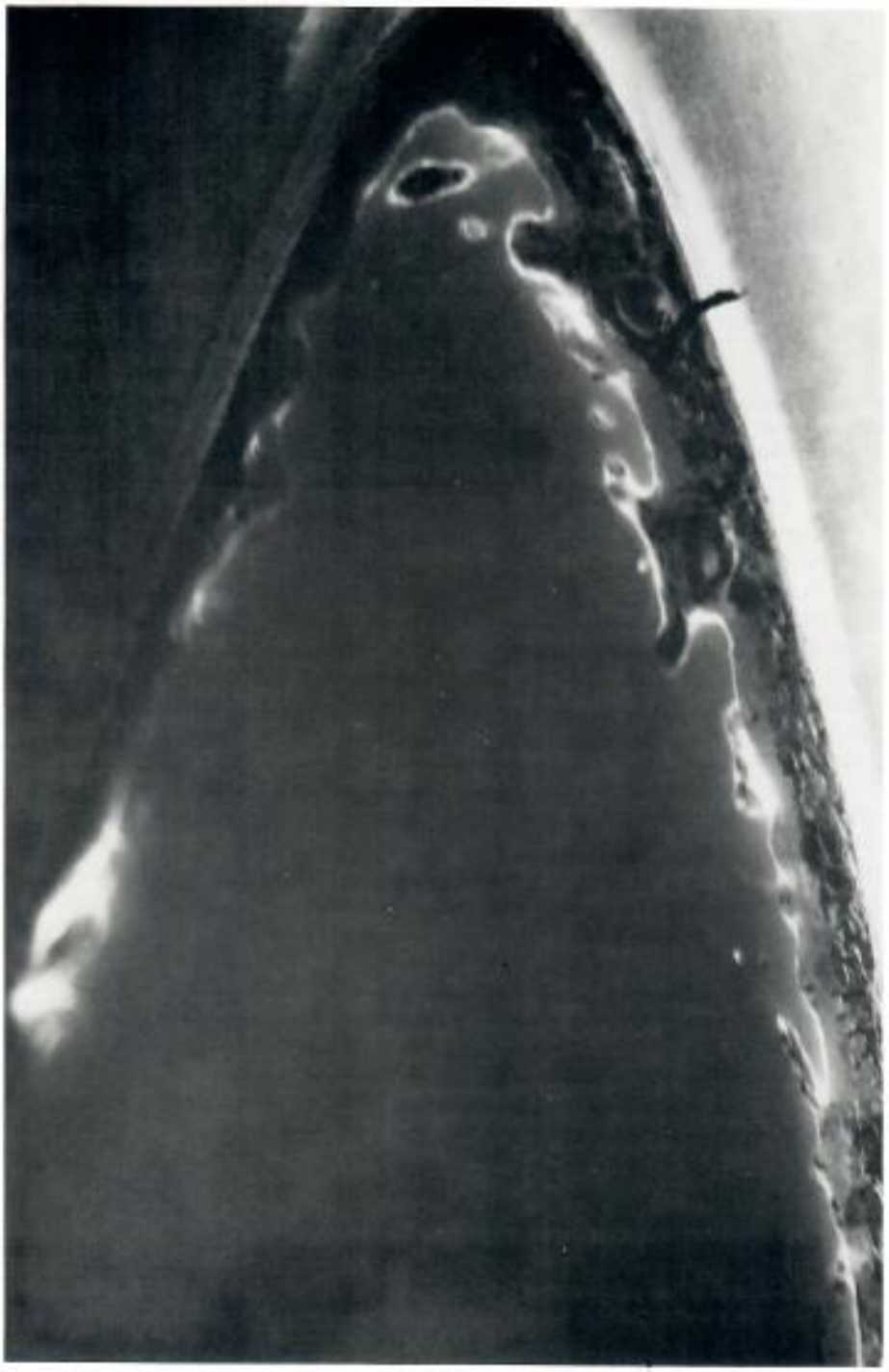


FIG. 2.—Photomicrograph of the tip of a wafer of peripheral bone of a captive *Chelonia mydas* (L.), experimental No. 386 sampled at 29 h after treatment; bright fluorescent line is most conspicuous on the ventral (right) surface of the bone; the inner ventral layer of keratin (farther right) shows bright autofluorescence.

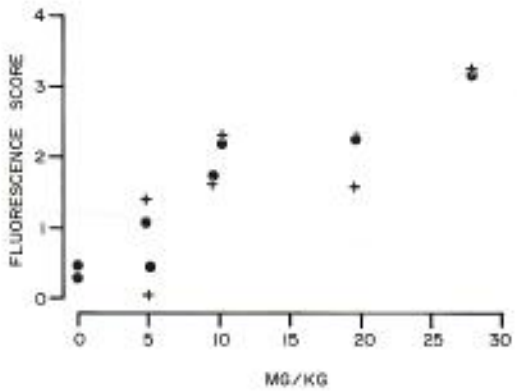


FIG. 3.—Relationship between fluorescence score (grand average) and dosage of oxytetracycline in captive *Chelonia mydas* (L.); solid circle = 29-hour sample; + = 139-day and 265-day samples.

showed stronger fluorescence than dorsal, and it was usually also brighter than the tip (Table 1). There is a strong relationship between fluorescence score and dosage (Table 1, Fig. 3). Experimental animals with dosages of about 5 mg/kg body weight showed little consistent difference from the controls. Progressively greater doses from 10–20–30 mg/kg body weight resulted in progressively brighter flourescent lines.

The 139-day sample showed no fluorescence in peripheral bone, humerus or femur. In contrast, the 265-day samples all had distinct fluorescent lines (Fig. 4). However, the dorsal surface usually glowed brighter than either the ventral surface or the tip. In general, the average score for each 265-day specimen was comparable to its 29-hour post-treatment score (Table 1, Fig. 3).

No simple relationship exists between wafer thickness and fluorescent score. There was no indication of any relationship between post-treatment deposition of bone and dosage of tetracycline for either dorsal or ventral surfaces, or for the overall average (respective values of $r = -0.49$, 0.13 and -0.18; $df = 3$). Dorsal growth was generally less than ventral; in four turtles the dorsal value was between 0.5 and 0.8 times that of the ventral, and in one specimen it was 1.4 times the ventral.

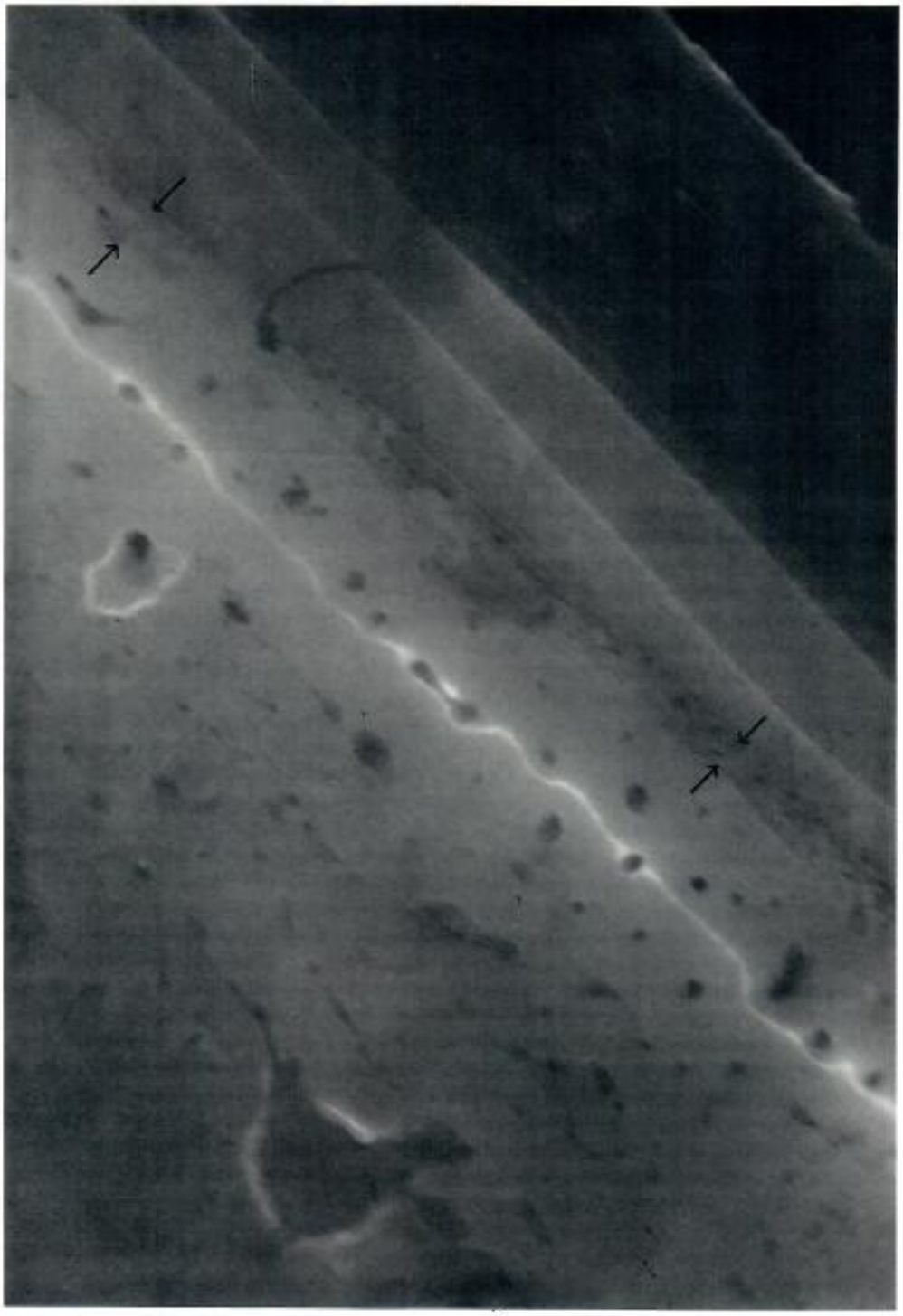
DISCUSSION

The dosages used in the present investigation were generally less than those used in other research on age determination in poikilothermic tetrapods, but few other comparisons can be made with herpetological studies because insufficient information was reported (Frazier, 1985). In the present experiment, dosage had no apparent effect on growth; there was no consistent difference in growth after 265 days between animals with low- and high-level doses, and all experimental animals showed body growth comparable to normal farm-reared animals. Repetitive doses of >30 mg/kg body weight may have an antiosteogenic effect.

The results are comparable with previously reported findings on tetracycline labeling, the majority of which deal with mammals. The intensity of fluorescence was related directly to tetracycline dosage level in green turtles. The intramuscular injections used in the present study had no obvious effect on the animals, and they were administered quickly and easily. The label, was incorporated rapidly; fluorescence was detected in green turtles within 29 h of treatment. Although diffuse, nonspecific fluorescence was conspicuous in the present study, it was generally less intense than fluorescence at the line of active bone growth, and it generally took on a more gold, less green color. The label is long-lasting: it was still conspicuous nearly a year after treatment in live animals and in labeled bone samples, nearly 3 yr after they were preserved by freezing.

→

FIG. 4.—Photomicrograph of the dorsal surface of a wafer of peripheral bone of a captive *Chelonia mydas* (L.); experimental No. 386, sampled at 265 days after treatment; the fluorescent line, periosteum (arrows) and laminated dorsal keratin are visible.



There was evidence of a photolytic effect. In the 29-hour samples, the labels on the ventral surfaces of the turtles' peripheral bones were consistently brighter and more distinctive than the labels on the dorsal surfaces, which were exposed to direct sunlight. Curiously, the converse applies to the 265-day samples, in which the dorsal labels were brighter. It is relevant, however, that in sample 381 the bright dorsal line is interrupted where the pigment in the shell above it is light rather than dark. Thus, is it possible that in the long run the fluorophor under the dorsal, dark-shelled surface was better protected than that on the ventral, light-shelled surface, but there is no simple explanation for reversals of relative fluorescent brightness in dorsal and ventral surfaces between the 29-hour and the 265-day samples.

There is no ready explanation for the absence of fluorescence in the 139-day sample of No. 384. The bones were thawed and possibly heated in the summer sun while in transit, and perhaps this destroyed the fluorophor. Castanet (in litt., 16 Dec. 1982) suggested that "bad" metabolism of the drug may account for the absence of a mark and the animal's death. This explanation is, however, difficult to accept, because the turtle in question was subjected to the lowest dosage of tetracycline administered in this experiment.

Conclusions

Oxytetracycline, when administered intramuscularly in doses of 5–28 mg/kg body weight, resulted in fluorescent lines in the periosteal region of peripheral bones of captive green turtles. Brighter fluorescence was found with stronger doses. The label was evidently laid down very rapidly and could be detected within 29 h, when ventral surfaces of the bones showed brighter fluorescence than did the dorsal surfaces. After nearly 9 mo, fluorescent lines were present, with about the same level of conspicuousness as was evident right after treatment; however, there was a reversal of the previous condition, for lines on the dorsal surfaces were brighter. Post-treatment deposition of bone appeared unrelated to dosage. In general, results with green turtles are consistent with those of earlier studies on other animals, particularly mammals, but few comparisons can be made with other herpetological studies.

A technique is available for quantifying the deposition rates of turtle bones, and applying this toward studies of growth and age determination. It should be possible not only to mark captive animals, but also to mark wild marine turtles; a pilot study is now being performed in Hawaii (Hohn, personal communication). The best label will be conspicuous yet have minimal effect on the animal; results of the present study indicate that dosage levels of about 30 mg/kg body weight will be suitable for green turtles.

Acknowledgments.—Drs. R. M. Bush, P. C. Mann, J. C. Mead and R. J. Montali generously loaned supplies and equipment and instructed in their use. Mr. Sheraton patiently helped with sampling, Dr. P. C. Mann with the microscopy, and Mrs. Wy Holden and Susana Salas with the typing. J. Castanet, C. K. Dodd, C. Gans, A. A. Hohn, R. F. Labisky, B. D. Ragsdale, J. Spotila, E. M. Smirina, G. R. Zug and two reviewers made valuable comments on earlier drafts. The assistance and hospitality of Dr. and Mrs. J. R. Wood and Cayman Turtle Farm made the study possible. Funding was provided by the Southeast Fisheries Center, National Marine Fisheries Service and Endangered Species Program, Region 2 of the U.S. Fish and Wildlife Service (NA81-GA-G-00018 and NA81-GF-A184), and Mr. J. Frazier, Sr. U.S. Fish and Wildlife permit PRT 2-4749 was used.

Literature Cited

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Ulrich, G. F., and A. S. Parkes. 1978. The green sea turtle (*Chelonia mydas*): further observations on breeding in captivity. J. Zool., Lond. 185:237–251.

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Department of Zoological Research, National Zoological Park, Smithsonian Institution, Washington, DC 20008, USA

National Zoological Park·Smithsonian Institution·Washington, D.C. 20008

April 1, 1980

Dr. George H. Balazs
University of Hawaii at Manoa
Hawaii Institute of Marine Biology
P.O. Box 1346
Coconut Island
Kaneohe, Hawaii 96744

Dear George:

Many thanks for your letter and very interesting enclosures of 17 March. I wish we had had time to chat in November; that was one busy meeting!

My presentations in Tampa were based on work in progress. The age-determination study is moving ahead; perhaps this summer I will have a sound manuscript. We have some interesting material already, but I want to close a few holes and get the technique down better, so that it can be widely applied.

The prospect of lens studies is certainly worth pursuing, but I have simply had to leave this for the time being to get on with other long-overdue studies.

I am writing the Postmaster General (see enclosed) and will phone to make sure they know we are interested.

All the best,

Jack

Jack Frazier

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Fisheries Center
Honolulu Laboratory
P. O. Box 3830
Honolulu, Hawaii 96812

November 16, 1981 F/SWC2:GHB

Ms. Aleta Hohn
Southwest Fisheries Center
National Marine Fisheries Service
P. O. Box 271
La Jolla, California 92038

Dear Aleta,

One of my contacts in the Fish and Wildlife Service recently sent me a copy of Jack Frazier's report of October 1, 1981, "Age determination studies in marine turtles," which was submitted to NMFS and FWS Endangered Species Program.

All of the plates shown in the report seem to illustrate the large bands or concentric lines that I described to you as having been seen in our attempts to section and polish bones here in Hawaii. I must have misunderstood you during our telephone conversation, because I thought you had told me that these were not the lines being looked at for age but rather some other component detectable in very thin sections.

My other comment, which is more of a helpful suggestion, is that you might try looking at some of the plastral bones, especially the hyoplaston. All of the plates in Jack's report show either femurs or humeri.

The nine turtles being held in captivity have now been dosed as we discussed, and 15 others were also treated before being released into the wild. We didn't notice any problems following injection, although the literature indicates that it can be somewhat painful.

I hope that your work is going well.

Sincerely,

George H. Balazs
Fishery Biologist

P.S.--Is there also a contract from the Fish and Wildlife Service for this aging work?

BONE AGING FILE

National Museum of Natural History · Smithsonian Institution
WASHINGTON, D.C. 20560 · TEL. 202- 357-2778

March 18, 1986

Dr. George Balazs
U. S. Department of Commerce, NOAA
National Marine Fisheries Service
D/swc2
P. O. Box 3830
Honolulu, Hawaii 96812

Dear George:

The Chelonia hatchlings from French Frigate Shoals arrived safely. Thank you for sending them. I am not going to rush to remove any humeri; at this point, I am trying to revise an iguana aging manuscript and complete a draft of a review of age determination techniques. Nonetheless it would be useful to have all the collection data that you have for these specimens, because it would be useful for us to catalogue them.

send

I have tentative plans to be in Oahu from 24-27 June, looking at Pacific lizards in the Bishop Museum. If you are in town and have a free hour or two, I would very much like to talk turtles with you.

Cordially,

George

George R. Zug
Curator-In-Charge
Division of Amphibians
and Reptiles

cc: Registrar

April 8, 1986 F/SWC2:GHB

Dr. George R. Zug
Curator-in-Charge
Division of Amphibians and Reptiles
Smithsonian Institution
NHB Stop 162
Washington, D.C. 20560

Dear George,

Many thanks for your letter of March 18th concerning our latest "aging" work using humeri from Hawaiian green turtles. I was hoping to see you in person at the recent sea turtle workshop in Waverly, Georgia, which I was fortunate to attend. I am sorry you couldn't be there. Enclosed is a brief summary of a presentation I gave on the occurrence of the fibropapillomas in our Hawaiian green turtles. Dr. John Harshbarger at the Smithsonian has been most helpful in identifying these neoplasms for me and suggesting profitable areas of research to determine their cause.

I regret to tell you that I probably won't be in Honolulu when you visit Bishop Museum June 24-27. At present, I am scheduled to be in the field monitoring and tagging nesting turtles at French Frigate Shoals starting May 29th and returning the evening of June 27th. Transportation to and from this site is by a small chartered aircraft. Other flights that occur during June have not yet been firmed up. If there is any possibility at all of my returning sooner, I will certainly try to do so. I feel that it is very important for us to sit down together and work on our aging data. It would seem a pity not to get this published in the near future.

If there is any change in your present schedule, please let me know. In the meantime, I'll do what I can to try to be here for the dates you indicated.

Sincerely,

George H. Balazs
Zoologist

Enclosure

cc: Balazs
HL

ID#	CL	Age: long axis	Age: short axis	Age: min age est.
Kailua 2		30*	24	9*
Lan 2-25-85		22	36	5
FFS Lgur		46*	-	21*
Kaal 5-77		298	85	85
Layson 9-78		29*	-	29*
FFS 6-80		69*	82	30*
Koh 3-85		154	-	54
Kauai 3-85		58	-	25
Kau 3		46*	51*	15*
Kauai 3-85		29*	10*	9*
Gary 1980		13	9*	5
Kane 6-82		19	15*	6
Maui 7-84		202*	209*	74*
Kau 4		74*	35*	15*
Lis 9-78		47*	-	22*
Kane 11-84		58	-	22
Kane 2-85		94	24	24
Bel 5/80		20*		7*
Mid 5-84		6	8	2
Bar Pt 85		29	12	10

NATIONAL MARINE FISHERIES SERVICE
HONOLULU LABORATORY
P. O. BOX 3830
HONOLULU, HAWAII 96812

SKELETAL SPECIMENS FOR AGE ESTIMATION OF HAWAIIAN GREEN TURTLES
(collected by George H. Balazs)

Specimen numbers	Maximum length (mm)	Weight (g)
Right humerus		
1. Lanai 2-25-85	72	14.0
2. Kaneohe 2-5-85	77	15.0
3. Kure 10-85	82	16.0
4. Gary 1980	84	19.0
5. Kaneohe 6-2-82	87	22.5
6. Kau 3	95	25.0
7. Kau 4	103	28.5
8. Bellows 5-14-80	106	40.0
9. Kawela 3-29-85	117	47.0
10. Hirota 1980	155	87.0
11. Kauai 3-6-85	168	111.0
12. Kaneohe 3-10-85	172	118.0
13. Kaneohe 28 Nov 84	172	149.0
14. Kahala 3-10-85	181	220.5
15. Laysan 9-78	194	181.0
16. Maui 7-27-84	197	198.0
17. Midway 5-84	212	212.0
18. FFS Tiger	--	115.0
Left humerus		
19. FFS 6-80	194	203.0
20. Kaalualu 5-77	197	145.5
21. Lisianski 9-78	203	223.0

Additional sections from right humerus sent 5-15-85

22. Barber's Pt. 4-29-85	203	3/3
23. Kadlua 1	80	19
24. Kailua 2	77	18

25. FFS hatchlings

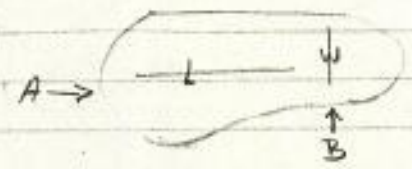
George:

Your note was a gentle prod, enough to have me examine the last few slides and complete the calculations. They seem much more variable than the last lot? Disease?

George
24 Jan

Kailua 1 - no MSA evident; aside from vascular canals, periosteal bone homogeneous

Kailua 2



Ectocto noice (mm) — Length bone

A 44.0, 113.05, 593.8 — 18.0 mm

B 23.8, 153.5 — 7.3 mm

Lgn 2-25-85

A 321.3, underneath layer of periosteum torn — 17.3 mm

B 428 um, — 6.1

Hirota 1980 no MSAs evident

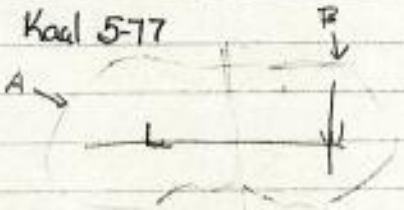
FFS Tiger

remodeling - numerous 2° osteons — Bone Length

A 605.7, 258.5, 230.9, 326.1, 577.2, — 29.7 mm

B — 20.0

Kaal 5-77

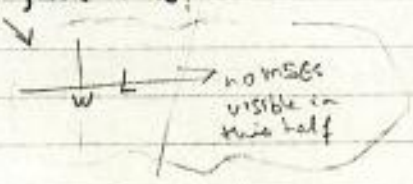


Secondary peculiarity

A 59.5, a single periph MSA — 38.5

B 28.6, 85.6 um — 18.3

Laysan 9-78



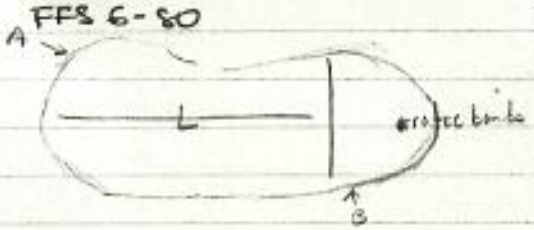
broad hm-og area

A 126.1, >1660, 341.5, 373.7 — L 39.5

B — W-19.2

Kane 3-85 No MSGs evident; strongly remodeled

FFS 6-80



A

A 122.6, 283.2, 311.8 L 359

B space, 221.3, — W - 17.4

Kah 3-85

A 117.5, only peripheral mat layer evident L 39.4

L ~ 2 wavy & interrupted laminae shows briefly in this area

W 15.7

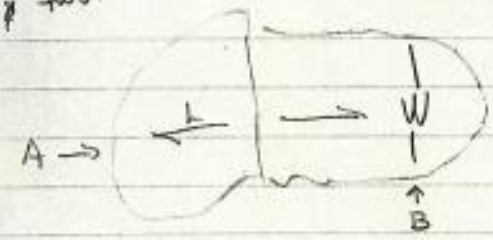
Kauai 3-85

A 285.6, another faint LAG deep inside L 36.3

W 14.4

Kau 3

* two halves don't match in width



...anti. LAG on other most MSG

A 104.7, 537.9, 541.4, 484.3 L 41.3

B. 77.4, 38.1, 75.0, 126.1, 258.2, 144.0 W 15.2

Kaua'i 3-85

A 374.8, 433.2, 373.7, 432.0, 449.8, 335.6 L 26.2

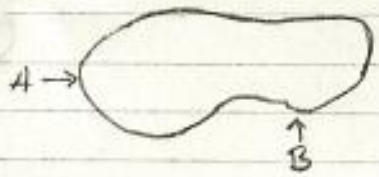
B 516.4, 270.1, 363.2, 341.5, 292.7, W 9.9

Gary 1980

A 573.6, 447.4 faint LAGs L 16.5

B. 345.1, 224.9, 198.7 very, very faint LAGs W 8.0

Kane 6-82



A 484.3 μm 21.6

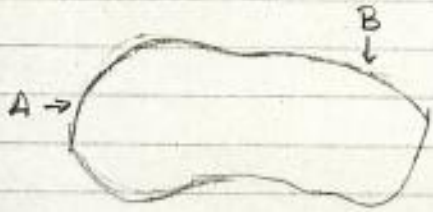
B 316.5, 139.2, 119.0 8.9 mm
lines very faint & visible only in thin areas

Kure 10-84

homogeneous only on outermost periosteal band is darkly stained 16.3

7.2

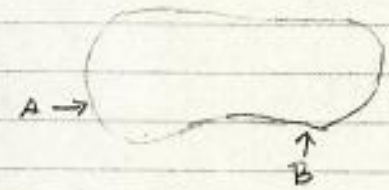
Maui 7-84



A. 88.4, 101.3, 126.2 38.7

B 25.9, 29.3, 38.9 16.1
~~41/68.2/38.9~~

Kau 4



A. 316.5, 158.3, 178.5, 130.9, 129.7, 109.5, 286.8, 113.0 20.4 mm

B. 152.3, 139.3, 35?, 56.8, 72.6, 130.9, 25.0, 21.4, 27.4 8.2 mm

2.8
15.4
47.6

Lio 9-78

A. 48.7, 38.0, 59.5, 147.6, 1234.0, 480.8 34.5

17.4

Kane 11-84

A 272.5 a single NEC visible at only one end. 34.8

15.5

Kane 2-85

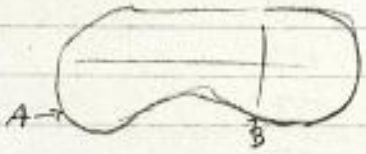
B 77.4 amazingly homog. except for single periph. MSG — 17.6 / 6.7

Bel 5-14-80

A very faint 321.1, 311.8, 414.1 + only in thin area — 23.3

~~321.8~~ 321.1 — 9.8

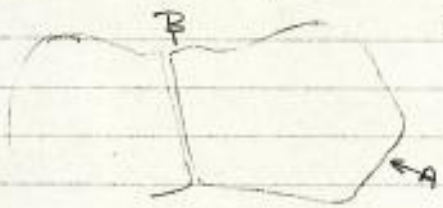
Mid E-84



A 1594.6 — 20.8 — 13.yr

B 348.7, 339.8 — 8.4 — 24.

Bar Ft 85



,105

A 109.4 new growth, 1332.8 — 45.3

B. 610.5 — 17.6

MSG/Age Estimate Calculation

		Long Axis A	Short axis B	
Kailua 2	Aver MSG width	250.3		(n=2)
		(n=3) $\bar{x}$ = 299.49	86.4	
2.15	shortaxis age estim	8.6	24.3	
7.5	long " " "	30.0	84.8	
Lan 2-25-85	Aver width	321.3 (n=1)	42.8	(n=1
3.55	short ax-age	4.8	36.2	
7.15	long " age	22.3	167.1	
FFS Tiger	Average	398.7 (n=5)		
		179.74		
5.5	short ax age	21.3		
15.3	long ax "	46.0		
Kaal 5-77	Average	59.5 (n=1)	107.1	
9.15	S/ age	153.8	85.4	
17.75	L/ age	298.3	165.7	
Laysan 9-78	Aver.	280.4 (n=3) 625.2 (n=4)	↓	
		$\bar{x}$ 134.63 698.49		
8.1	S/ age	28.9	13.0	
18.25	L/ age	65.1	29.2	
FFS 6-80	Aver	239.2 (n=3)	221.3 (n=1)	
16.45	S/age	30.1	32.5	
16.45	L/ age	68.8	74.3	
Kah 3-85	Aver	177.8 (n=1).		
6.35	S/age	53.9		
18.2	L/age	154.5		
Kauai 3-85	Aver	265.6 (n=1)		
7.05	S/age	24.7		
16.65	L/age	58.3		

		long axis A	short axis B
Kau 3	Aver	417.1 (n=4)	119.8 (n=6)
	Δ	= 209.88	= 77.79
6.1	S/age	14.6	50.9
19.15	L/age	~~91.2~~ 45.9	159.8
Kauai 3-85	Aver	399.8 (n=6)	333.2 (n=5)
	Δ	44.90	50.58
3.45	S/age	8.6	10.4
11.6	L/age	29.0	34.8
Gary 1980	Aver.	510.5 (n=2)	272.9 (n=3)
	Δ		106.64
2.5	S/age	4.9	9.2
6.75	L/age	13.2	24.7
Kaue 6-82	Aver	484.3 (n=1)	191.6 (n=3)
	Δ		108.87
2.95	S/age	6.1	15.4
9.3	L/age	19.2	48.5
~~Kure 10-84~~	Aver	88.6 (n=3)	31.4 (n=3)
Maui 7-84	Δ	45.25	6.7
6.55	S/age	73.9	208.6
17.85	L/age	201.5	568.5
Kau 4	Aver	171.9 (n=8)	74.2 (n=9)
	Δ	80.07	5261
26	S/age	117.3	35.0
8.7	L/age	73.8	14.6
Lis 9-78	Aver	333.6 (n=6)	
	Δ	472.17	
7.2	S/age	21.6	
15.75	L/age	47.2	

		forgoers A	stayers B
Kane 11-84	Aver	272.5 (n=1)	
	6.1 S/age	22.4	
	15.9 L/age	58.3	
Kane 2-85	Aver		77.4 (n=1)
	1.85 S/age		23.9
	7.3 L/age	94.3	
Bel 5-14-80	Aver.	515.7 (n=3)	
	3.4 S/age	6.6	
	10.15 L/age	19.7	
Mid. 5-84	Aver	1594.6 (n=1)	344.3
	2.7 S/age	1.7	7.8
	8.9 L/age	5.6	25.8
Bar Pt. 85	Aver	721.1 (n=2)	610.5 (n=1)
	7.3 S/age	10.1	12.0
	21.15 L/age	29.3	34.6