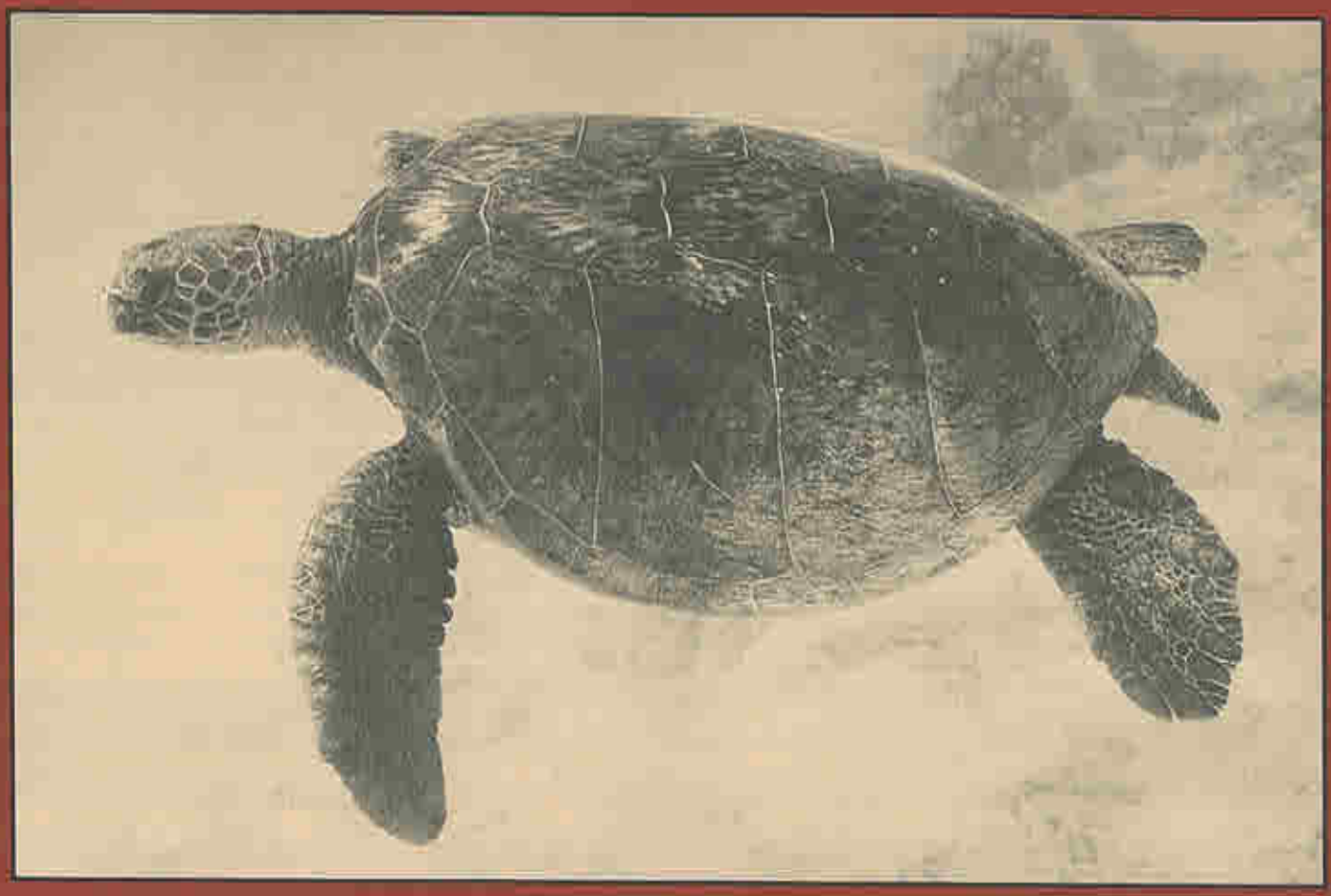
MANUAL OF SEA TURTLE RESEARCH AND CONSERVATION TECHNIQUES

prepared for the
Western Atlantic Turtle Symposium

San Jose, Costa Rica, 17-22 July 1983
Sponsored by IUCN/SSC



Second Edition
November 1983

MANUAL OF SEA TURTLE RESEARCH AND CONSERVATION TECHNIQUES

Prepared for the
Western Atlantic Turtle Symposium

A Symposium on
Sea Turtle Research
in the Western Central Atlantic
(Populations and Socio-economics)

in San Jose, Costa Rica: 17-22 July 1983
Sponsored by IOCARIBE

Second Edition
July 1983

Center for Environmental Education
Washington, D.C.

PAGE INTENTIONALLY LEFT BLANK

MANUAL OF SEA TURTLE RESEARCH AND CONSERVATION TECHNIQUES

AUTHORS

Peter C. H. Pritchard
Florida Audubon Society
1101 Audubon Way
Maitland, Florida 32751 U.S.A.

Peter R. Bacon
Zoology Department
University of the West Indies
Box 12 Mona
Kingston, Jamaica

Frederick H. Berry
Southeast Fisheries Center
National Marine Fisheries
Service, NOAA
75 Virginia Beach Drive
Miami, Florida 33149 U.S.A.

Archie F. Carr
Department of Zoology
University of Florida
Gainesville, Florida 32611 U.S.A.

John Fletemeyer
Ocean Sciences Center
Nova University
Dania, Florida 33004 U.S.A.

Robert M. Gallagher
Chemical and Environmental
Sciences, Inc.
1038 NE Hansen Terrace
Jensen Beach, Florida 33457 U.S.A.

Sally R. Hopkins
South Carolina Wildlife and Marine
Resources Department
P.O. Box 12559
Charleston, South Carolina 29412 U.S.A.

Robert R. Lankford
IOC Assistant Secretary for
IOCARIBE
c/o UNDP
Apartado #4540
San Jose, Costa Rica

Rene Marquez M.
Instituto Nacional de Pesca
Delegacion Federal de Pesca
Teniente Azueta S/N
Manzanillo, Col. 28200, Mexico

Larry H. Ogren
Southeast Fisheries Center
National Marine Fisheries
Service, NOAA
Panama City Laboratory
3500 Delwood Beach Road
Panama City, Florida 32407 U.S.A.

William G. Pringle, Jr.
1 Notch Road
West Simsbury
Connecticut 06092 U.S.A.

Henry A. Reichart
STINASU
PO Box 436
Paramaribo, Suriname

Ross Witham
Florida Department of
Natural Resources
100 Eighth Avenue, S. E.
St. Petersburg, Florida 33701
U.S.A.

This second edition was edited by

Karen A. Bjorndal
Department of Zoology
University of Florida
Gainesville, Florida 32611 U.S.A.

and

George H. Balazs
Southwest Fisheries Center
National Marine Fisheries Service, NOAA
Honolulu Laboratory
P.O. Box 3830
Honolulu, Hawaii 96812 U.S.A.

and was reviewed by

Peter R. Bacon
Frederick H. Berry
John Fletemeyer
Robert R. Lankford
Rene Marquez M.
Larry H. Ogren
Peter C. H. Pritchard
Henry A. Reichart
Ross Witham

Cover photo credit: G. H. Balazs. This Second Edition is also printed separately in Spanish.

This document should be cited as follows:

Pritchard, P.; P. Bacon; F. Berry; A. Carr; J. Fletemeyer; R. Gallagher; S. Hopkins; R. Lankford; R. Marquez M.; L. Ogren; W. Pringle, Jr.; H. Reichart and R. Witham. 1983. Manual of sea turtle research and conservation techniques, Second Edition. K. A. Bjorndal and G. H. Balazs, editors. Center for Environmental Education, Washington, D.C.

The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the Intergovernmental Oceanographic Commission and of the Food and Agriculture Organization of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Table of Contents

List of Figures 7

List of Sea Turtle Data Record Forms 8

A. Purpose of this Manual 9

A.1 Acknowledgements 9

B. Requirements for a Program of Sea Turtle Conservation 10

C. Survey Techniques 12

C.1 Identification of Species 12
C.1.1 Scientific and Vernacular Names 12
C.1.2 Identification of Adult and Juvenile Sea Turtles 13
C.1.3 Identification of Hatchlings 24
C.1.4 Identification of Tracks and Nests 24
C.1.5 Species Identification Problems 29

C.2 Aerial Surveys 32
C.2.1 Aerial Beach Survey 32
C.2.2 Ground Truth Survey for Aerial Beach Surveys 48
C.2.3 Survey Charts 54
C.2.4 Pelagic Aerial Surveys 54
C.2.5 Other Aerial Observations 56

C.3 Vessel Surveys 56
C.3.1 Data Recording Forms: Vessel Survey Records 57

C.4 Ground Surveys 60
C.4.1 Nesting Beach Surveys 60
C.4.2 How to Measure Sea Turtles 62
C.4.3 Tagging Sea Turtles 68
C.4.4 Data Form for Sea Turtle Beach Surveys 73
C.4.5 Determination of Hatching Success 75

C.5 Market Surveys 77
C.5.1 Types of Data to Collect on Market Surveys 77

C.6 Suggestions for Conducting Interviews 78
C.6.1 Draft Questionnaire 81

D. Management and Conservation 85

D.1 Beach and Nest Protection 86
D.1.1 Control of Predation by Man 86
D.1.2 Control of Domestic Predators 87
D.1.3 Control of Wild Predators 87
D.1.4 Protection from Beach Erosion 87
D.1.5 Protection from Later Nesting Turtles 87
D.1.6 Egg Handling and Relocation 88
D.1.7 Release of Hatchlings 92

D.2 Incidental Catch 92
D.2.1 Background 92
D.2.2 Avoidance of Incidental Catch 92

Table of Contents (Continued)

D.2.3 Resuscitation of Apparently Drowned Sea Turtles..... 93

D.3 Legislation and Enforcement..... 94
D.3.1 National Conservation Legislation..... 94
D.3.2 International Conservation Legislation..... 95
D.3.3 Techniques for Setting Up Turtle Reserves..... 96

D.4 Care of Sea Turtles in Captivity..... 98
D.4.1 Culture Techniques and Requirements..... 98
D.4.2 Turtle Aquaculture for Conservation or Population Restoration Efforts..... 100

E. Glossary of Terms..... 101

F. Sea Turtle References..... 106

Annex 1. Color Plates..... 108

List of Figures

Figure

1 Silhouettes of sea turtles..... 15
2 An illustrated guide to morphological terms..... 16
3 *Lepidochelys kempi* (Kemp's ridley)..... 17
4 *Lepidochelys olivacea* (olive ridley)..... 18
5 *Eretmochelys imbricata* (hawksbill)..... 19
6 *Caretta caretta* (loggerhead)..... 20
7 *Chelonia mydas* (green turtle)..... 21
8 *Chelonia depressa* (flatback)..... 22
9 *Dermochelys coriacea* (leatherback)..... 23
10 Two typical nesting positions..... 25
11 Various crawl tracks and nest marks..... 26
12 Measuring carapace length: straight-line method..... 63
13 Measuring carapace length: curved-line method..... 64
14 Anatomical points for measuring carapace length..... 65
15 Measuring carapace width: straight-line method..... 66
16 Tail measurements..... 67
17 Commonly used turtle tags..... 69
18 Method of tagging..... 70
19 Suggested design for in-ground hatchery..... 90

List of Sea Turtle Data Record Forms

Form

1 Sea Turtle Aerial Beach Survey: Zone Records..... 38
1a Completed Sample of Form 1..... 39

2 Sea Turtle Aerial Beach Survey: Flight Data Records..... 41
2a Completed Sample of Form 2..... 42

3 Sea Turtle Aerial Beach Survey: Flight Data Records..... 43
3a Completed Sample of Form 3..... 44

4 Sea Turtle Aerial Beach Survey: Ground Truth Beach Survey.... 50
4a Completed Sample of Form 4..... 51

5 Sea Turtle Aerial Beach Survey: Ground Truth Beach Survey.... 52
5a Completed Sample of Form 5..... 53

6 Sea Turtle Vessel Survey..... 58

7 Sea Turtle Tagging and Nesting Data Form--Beach Survey..... 74

8 Sea Turtle Egg and Hatchling Data Form..... 76

MANUAL OF SEA TURTLE RESEARCH AND CONSERVATION TECHNIQUES

A. Purpose of this Manual

This manual was prepared primarily to assist in planning and research for the 1982 and 1983 field research programs of the Western Atlantic Turtle Symposium (WATS) or the Simposio sobre Tortugas del Atlantico Occidental (STAO). This Symposium on Sea Turtle Research in the Western Central Atlantic (Populations and Socio-Economics) is being planned and sponsored by the Intergovernmental Oceanographic Commission Association for the Caribbean and Adjacent Regions (IOCARIBE) with the cooperation of the UNDP/FAO Inter-regional Fisheries Development and Management Program (WECAF).

The multiple co-authors and editors all made significant contributions to this manual. They recognize that agreement in all aspects of sea turtle research methods and conservation has not been reached; a variety of methodologies appear in the published literature. Moreover, research techniques often depend upon local customs and circumstances. Rather than include every known technique or involve the readers in extensive debates, we give the techniques we jointly consider "recommended" or "preferred," followed where appropriate by "alternatives." In similar fashion, we offer draft outlines of the types of data recording forms that have proved successful in sea turtle surveys.

This effort, planned as an initial working document for the western Atlantic area and its six sea turtle species, has been broadened slightly to include the other species, the flatback turtle of Australia and Papua New Guinea, and the black turtle of the eastern Pacific.

A.1 Acknowledgements

This manual was prepared under the sponsorship of the Intergovernmental Oceanographic Commission Association for the Caribbean and Adjacent Regions (IOCARIBE).

The Manual preparation was supported in the early draft stages by the UNDP/FAO Inter-regional Fisheries Development and Management Program (WECAF), and throughout its preparation by the Southeast Fisheries Center of the U.S. Department of Commerce, National Marine Fisheries Service (NMFS).

Later editing of the first edition of the Manual and preparation of some illustrations were supported by the grant from the Sea Turtle Rescue Fund, a project of the Center for Environmental Education, Washington, D.C.

The drawings were prepared by Marvin Bennett of Orlando, Florida, and John Datillo, Applied Biology, Inc., Atlanta, Georgia. Portions of Figures 3, 5, 6, and 7 are adapted from Brongersma, L. D. 1967. *British Turtles*. British Museum of Natural History, London.

The authors are grateful to the following for editorial comments on the penultimate manuscript draft of the first edition: George H. Balazs, Thomas H. Fritts, David J. Herrera, Sally Hopkins, Albert Jones, Charles Karnella, Anne Meylan, Nicholas Mrosovsky, Charles A. Oravetz, Robert Shoop, Nancy Thompson and Michael Weber. Additional comments for the second edition were received from C. Kenneth Dodd, Jr., Nat Frazer, Andreas Mager, Jr., and Douglas Robinson.

The Spanish version of the Manual was translated by Pedro E. Leon, and was edited by Douglas Robinson, both of the University of Costa Rica, San Jose.

The final manuscripts of the first edition were typed and compiled by Maria Teresa Koberg, San Jose, Costa Rica. Camera-ready copy of the second edition was prepared by Grace Russell, Ginny Lawman and Evelyn Rockwell, Gainesville, Florida.

B. Requirements for a Program of Sea Turtle Conservation

The nature of local turtle populations and constraints on time, resources and manpower determine the requirements and components of turtle programs. A critical need is for scientific data: which species occur where; local and regional population sizes; and historical population sizes. Knowing the nature and extent of human exploitation and any other features that may affect the sea turtle populations is also important. Usually the research program will stress the terrestrial phase of the life cycle--nesting females, eggs, and hatchlings. Consequently, most research will take place during the few months of the nesting season. The distinct ecology and migratory habits of different species must be understood for scientific conservation.

B.1 Species Identification

Species identification, which may be made at any developmental stage from embryo to adult, is essential. Identification can also be made from tracks and nests.

B.2 Habitat Description and Inventory

The first stage of any survey should consist of recording and classifying the types and distribution of existing coastal habitats which are, or may be, used by sea turtles. This inventory may be done at any time of year, but must be updated as data accumulate from other aspects of the program. A survey of beach types is essential for detailed planning of aerial and ground surveys. Pelagic surveys can provide valuable information on foraging areas and migrations.

B.3 Survey Techniques

For ground surveys, sampling unit areas must be established to facilitate later statistical analysis of data. The Manual explains what to look for, how to measure and tag turtles, and how to estimate hatching success. These factors form the basis of accurate population estimates.

The best way to ensure that survey data are accurately recorded is to use standardized data record sheets prepared in advance and available to all survey team members.

B.4 Sea Turtle Exploitation Surveys

Biological data must be supplemented by assessments of human impact. What vessels are operating in the area? What is the fishery and incidental catch rate? How and where are products marketed, both locally and internationally? A number of sources, including official statistics and interviews with fisherman and local residents, can yield such data.

B.5 Sea Turtle Protection Techniques

The key to management and conservation is protecting the remaining sea turtle stocks under conditions which are as natural as possible. A sea turtle program should consider the control of all predators, the control or prevention of other causes of mortality, and the protection of eggs and nests.

Turtle populations cannot be conserved and restored unless fishermen, vendors and the public cooperate. A complete sea turtle program must consider legislation and its enforcement, the establishment and the protection of sanctuaries, continuous population monitoring and public education.

B.6 Captive Maintenance of Sea Turtles

Although this Manual does not address commercial turtle culture, it outlines optimal conditions for maintaining juvenile and adult turtles in captivity where such cultures are practical and beneficial.

B.7 Summary

An effective sea turtle research and conservation program is complex and could become expensive. We have attempted to provide sufficient information for anyone wishing to embark on some or all of the aspects involved. We emphasize that the status of many of the world's turtle populations is changing rapidly. All sea turtle observations, whether a single sighting or the records of an entire season's nesting, are potentially of great value. Only if they are recorded and reported will such data be available for planning conservation programs.

C. Survey Techniques

C.1 Identification of Species

C.1.1 Scientific and Vernacular Names

Many different vernacular or common names are used throughout the world. In some areas, local fisherman have several names for slightly different color phases or age cohorts of the same species. Except for *Chelonia depressa* which is confined to the Indo Pacific region, the names that appear most regularly in popular and scientific literature and that fishermen of the Caribbean and western Atlantic use commonly are:

a) *Lepidochelys kempi*:
Kemp's ridley (Preferred English)
Tortuga lora del Atlantico (Preferred Spanish)
Atlantic ridley
Gulf ridley
Grey loggerhead
Tortuga boba (Latin America)
Bastard turtle (old literature)

b) *Lepidochelys olivacea*:
Olive ridley (Preferred English)
Tortuga golfina (Preferred Spanish)
Pacific ridley
Warana (Suriname)
Tortue olivatre (French Guiana)
Xibirro (Brazil)

c) *Eretmochelys imbricata*:
Hawksbill (Preferred English)
Carey (Preferred Spanish)
Oxbull (Caribbean English)
Caret (French)
Tortue des bonnes ecailles (French)
Tortue imbriquee (French Guiana)
Karet (Suriname)
Tartaruga de pente (Brazil)

d) *Caretta caretta*:
Loggerhead (Preferred English)
Caguama (Preferred Spanish)
Cabezona
Logrit (Caribbean English)
Onechte karet (Suriname)
Caouane (French Guiana)
Avo de tartaruga (Brazil)
Jabalina (Mexico, Pacific coast)

e) *Chelonia mydas*:
Green turtle (Preferred English)
Tortuga verde (Preferred Spanish)
Greenback turtle (Caribbean English)
Edible turtle

		Soup turtle Tortue verte (French Guiana) Tortuga blanca (Mexico, Atlantic coast) Tartaruga verde (Portuguese) Aruana (Brazil) Krape (Suriname)
f)	*Chelonia agassizi*:[1,2]	Black turtle (Preferred English) East Pacific green turtle Caguama prieta (Mexico, Pacific coast) Tortuga prieta (Mexico, Pacific coast)
g)	*Chelonia depressa*:[2]	Flatback (Preferred English) (no common name in Spanish) Kikila (Daugo Island, Papua New Guinea) Usi vidi (Paredaba Village, Central Province, Papua New Guinea)
h)	*Dermochelys coriacea*:	Leatherback (Preferred English) Tinglada (Preferred Spanish) Leathery turtle Trunk turtle (Caribbean English) Trunkback Tortue luth (French Guiana) Coffinback (Trinidad) Caldong (Trinidad) Siete filos (Latin America) Chalupa (Latin America) Baula o laud (Latin America) Aitkanti (Suriname) Tartaruga de couro (Brazil) Canal (Panama) Machincuepo (Mexico, Pacific coast) Garapachi (Mexico, Pacific coast)

C.1.2 Identification of Adult and Juvenile Sea Turtles

C.1.2.1 Air Survey Identification

I, II. Disc-shaped, virtually as wide as long, medium sized head: *Lepidochelys*. Dorsal coloration grey in juveniles, olive green in adults. (Species of *Lepidochelys* can only be identified when in hand; *L. kempi* is restricted to Gulf of Mexico and Northern Atlantic; *L. olivacea* occurs in Pacific, Indian, and South Atlantic oceans, with rare strays reported from the Caribbean.)

[1] The majority of extant texts assume that there are seven valid species of sea turtles in the world. However, a growing body of opinion and evidence recognizes the black turtle of the Eastern Pacific as a full species, *Chelonia agassizi*, rather than as a subspecies of the green turtle, *Chelonia mydas*, and this opinion is accepted here.

[2] Not found in West Atlantic.

Lepidochelys kempi (Kemp's ridley) and
L. olivacea (olive ridley).....Figure 1,a

III. Heart-shaped or elongate, tapering behind, with strong posterior serrations on carapace in most cases; head narrow and pointed. Carapace brown with variable light radiating markings.
Eretmochelys imbricata (hawksbill).....Figure 1,b

IV. Somewhat elongate, tapering behind; very large, triangular head; overall color reddish brown.
Caretta caretta (loggerhead).....Figure 1,c

V. Nearly oval or somewhat tapering behind; small rounded head. Color variable--dorsal scutes may be radially streaked, spotted or almost plain.
Chelonia mydas (green turtle).....Figure 1,d
Chelonia agassizi (black turtle)..is similar, but darker on the dorsal side

VI. Carapace broadly oval, not tapering behind; head small and rounded. Dorsal coloration yellowish-grey (confined to Northern Australia and adjacent waters).
Chelonia depressa (flatback).....Figure 1,e

VII. Body elongate with longitudinal ridges; head medium and rounded; fore flippers very long; overall color black, variable white spotting; adult size very large--up to 2 m.
Dermochelys coriacea (leatherback).....Figure 1,f

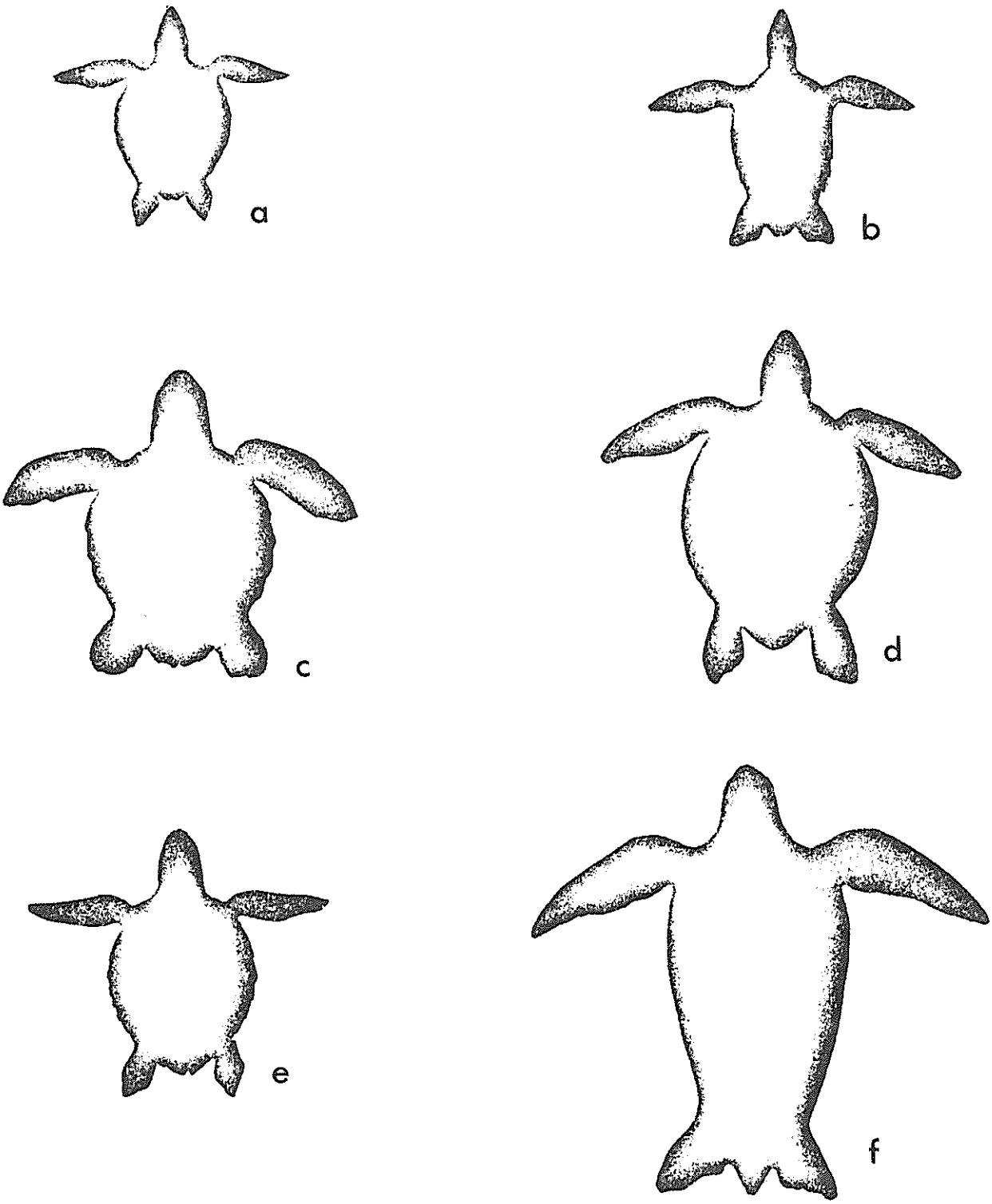


Figure 1. Silhouettes of sea turtles viewed from the air; a relative scale is used. 1,a: *Lepidochelys kempi* (Kemp's ridley) and *L. olivacea* (olive ridley); 1.b: *Eretmochelys imbricata* (hawksbill); 1,c: *Caretta caretta* (loggerhead); 1,d: *Chelonia mydas* (green turtle); 1,e: *Chelonia depressa* (flatback); 1,f: *Dermochelys coriacea* (leatherback).

C.1.2.2 Simplified Key to Species (Refer to Figure 2 and Colored Plates 1-32 in Annex I)

1. Leathery shell with seven longitudinal keels, (*Dermochelys coriacea*: leatherback)
1a. Hard shell with horny scutes.....see 2
2. One pair of prefrontal scales (between eyes and nostrils)..see 3
2a. Two pairs of prefrontal scales.....see 4
3. Three scales behind each eye; carapace with upturned margins, (*Chelonia depressa*: flatback)
3a. Four scales behind each eye; carapace heart-shaped without upturned sides, (*Chelonia mydas* and *Chelonia agassizi*: green turtle and black turtle)
4. Four pairs of large scutes (laterals) on each side of carapace, (*Eretmochelys imbricata*: hawksbill)
4a. More than four pairs of lateral scutes.....see 5
5. Reddish-brown upper body surface; plastron with three pairs of enlarged scutes (inframarginals) connecting it to the carapace, (*Caretta caretta*: loggerhead)
5a. Grey or olive upper body surface; plastron with four pairs of enlarged scutes (inframarginals) connecting it to carapace.....see 6
6. Five pairs of lateral scutes on carapace, (*Lepidochelys kempi*: Kemp's ridley)
6a. Six or more pairs (rarely five) of lateral scutes, (*Lepidochelys olivacea*: olive ridley)

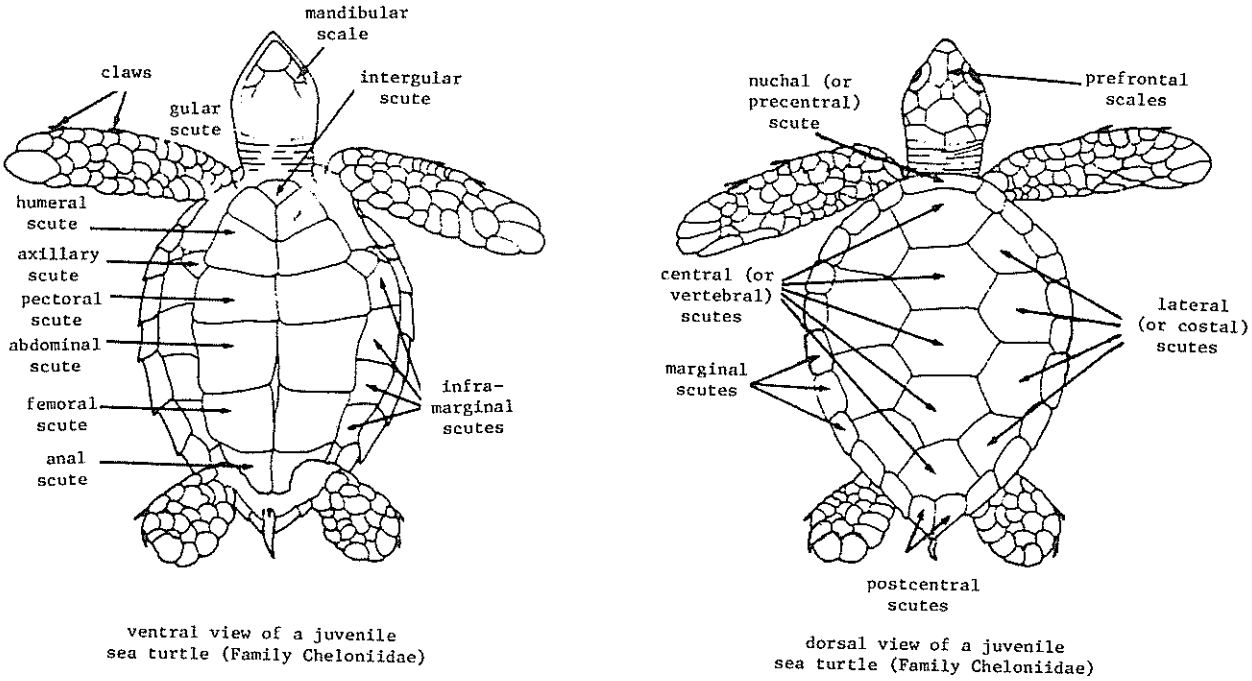


Figure 2. An illustrated guide to morphological terms. *Modified from:* Fischer, W. (Ed.). (1978). *FAO Species Identification Sheets for Fisheries Purposes.* Western Central Atlantic (Fishing Area 31), Vol. VI.

C.1.2.3 Identification of Turtles Available for Close Examination

In addition to features listed in C.1.2.1, look for the following:

a) Five pairs of lateral scutes. Head to about 13 cm wide. Carapace, to about 70 cm long (straightline measurement). Two pairs of prefrontal scales. A pore near the rear of each inframarginal. Carapace scutes do not overlap. Dorsal color grey in immatures, light olive-green in adults. White below in immatures, yellow below in adults. Weight to 45 kg.
Lepidochelys kempi (Kemp's ridley).....Figure 3

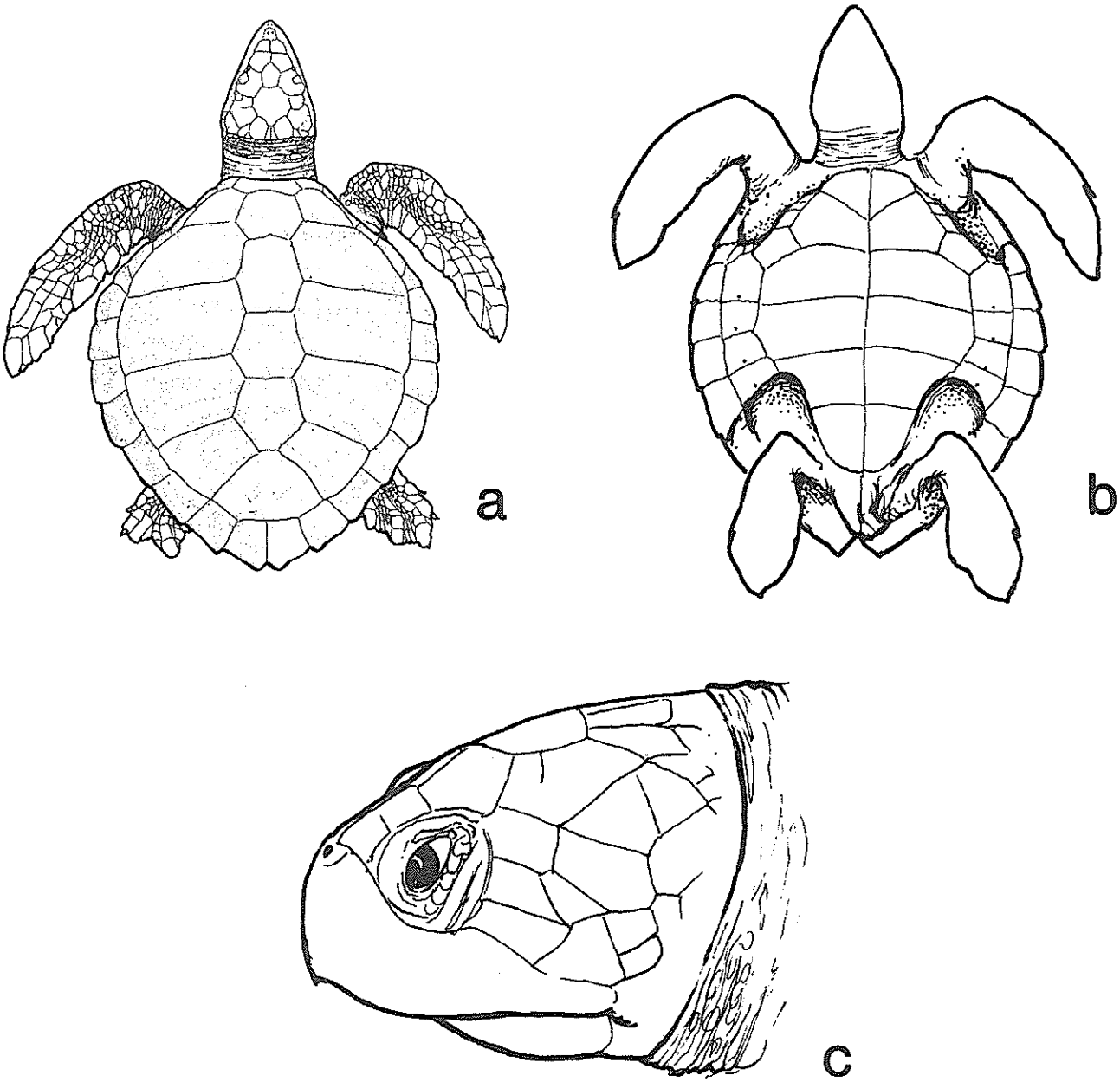


Figure 3. *Lepidochelys kempi* (Kemp's ridley), 3,a: dorsal view; 3,b: ventral view; 3,c: head view.

b) Five to nine pairs of lateral scutes (usually six to eight). Head up to about 13 cm wide. Carapace, up to 70 cm long. Two pairs of prefrontal scales. A pore near the rear of each inframarginal. Carapace scutes do not overlap. Color grey above in immatures, dark olive-green in adults. White below in immatures, yellow below in adults. Head to about 13 cm wide. Weight to 45 kg.
Lepidochelys olivacea (olive ridley).....Figure 4

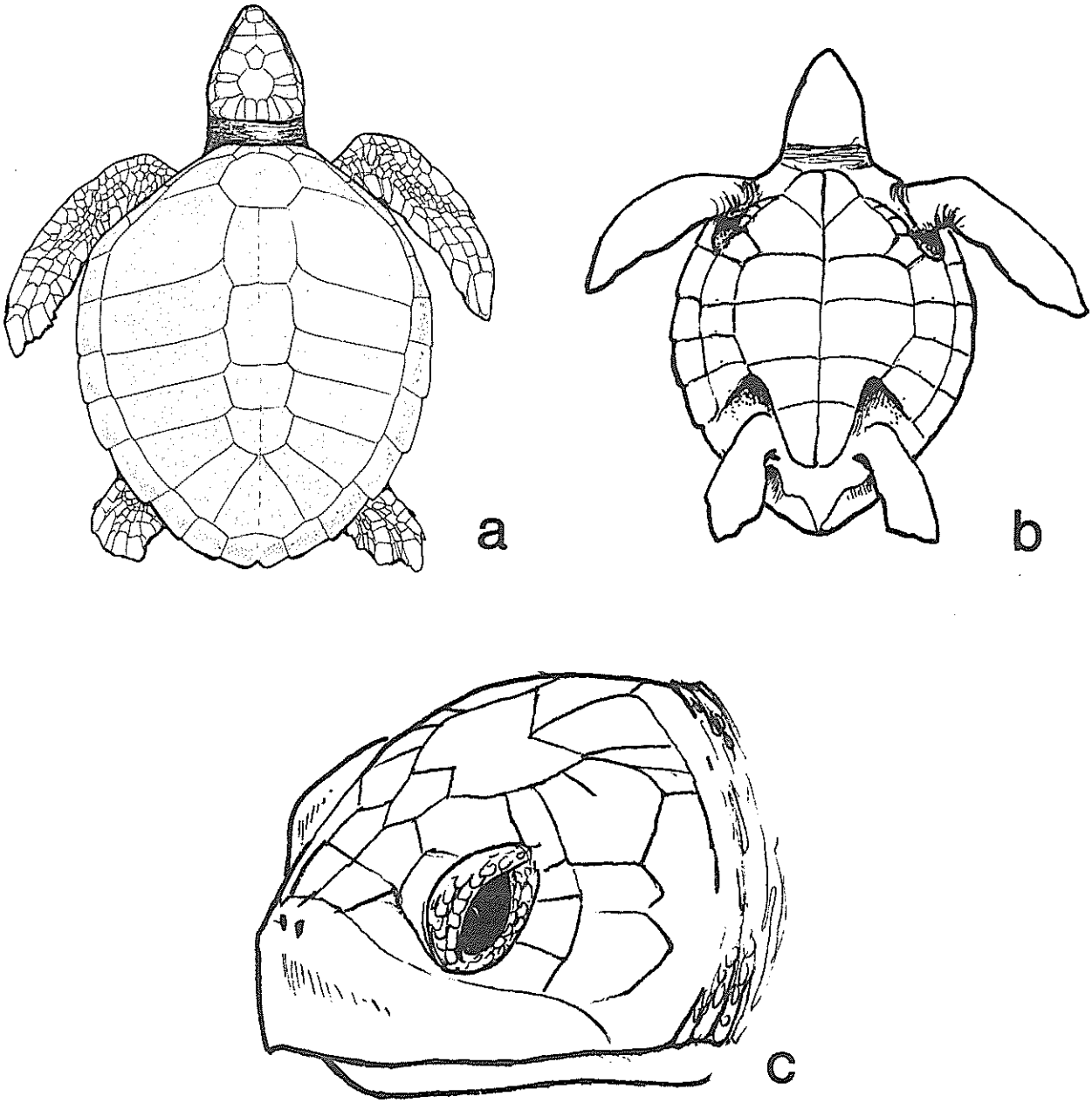


Figure 4. *Lepidochelys olivacea* (olive ridley); 4,a: dorsal view; 4,b: ventral view; 4,c: head view.

c) Four pairs of lateral scutes. Head, to about 12 cm wide. Carapace, to about 90 cm long. Two pairs of prefrontal scales. Carapace scutes thick and overlapping (except in hatchlings and old individuals). Dorsal color very variable, usually predominately brown with dark and light spots and streaks. Underside light yellow or white, sometimes with black spots (especially in juveniles from Pacific). Weight to 80 kg.
Eretmochelys imbricata (hawksbill).....Figure 5

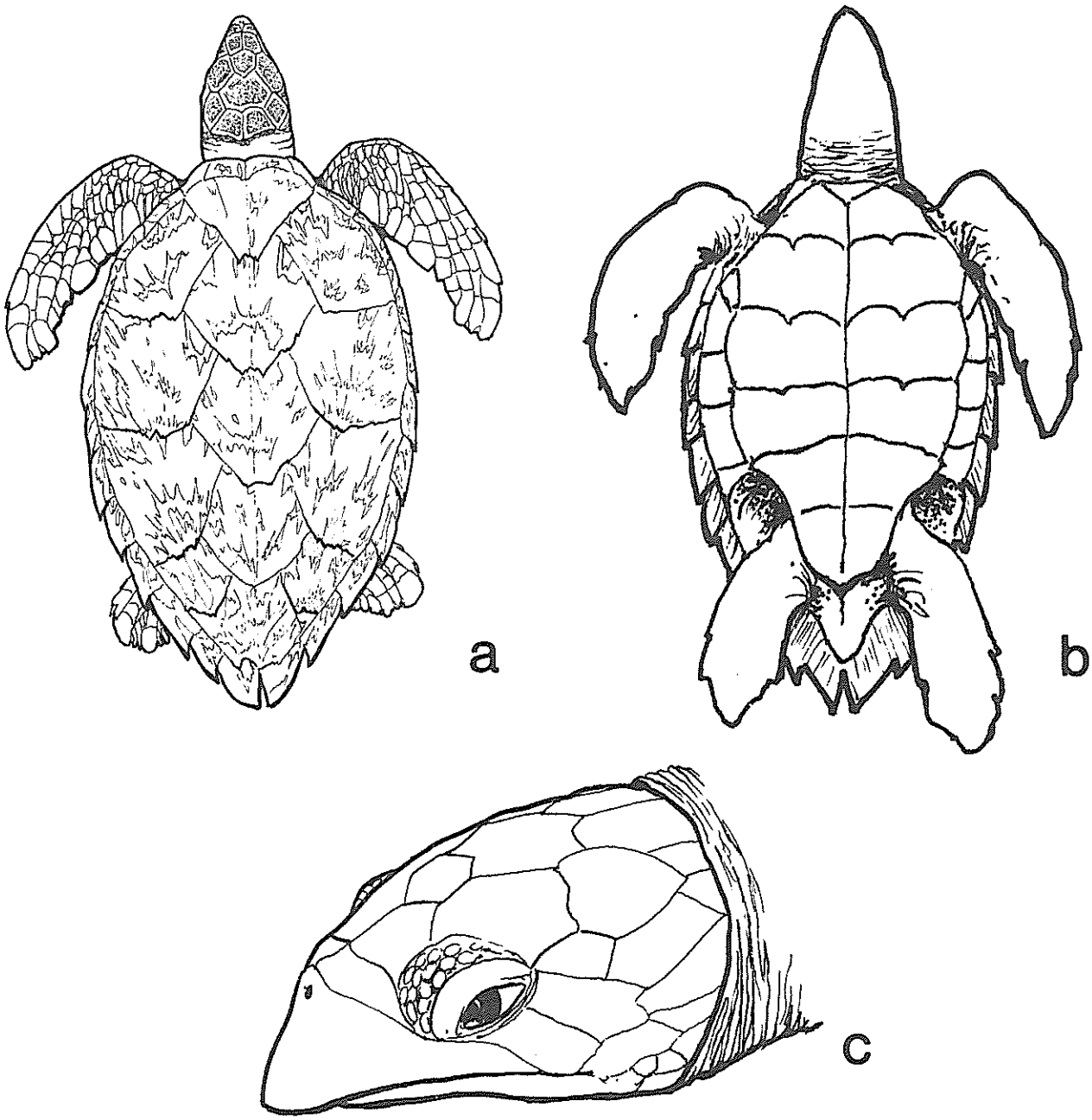


Figure 5. *Eretomochelys imbricata* (hawksbill); 5,a: dorsal view; 5,b: ventral view; 5,c: head view.

d) Five pairs of lateral scutes. Head, to about 25 cm wide. Carapace, to 120 cm long. Two pairs prefrontal scales. Carapace scutes not overlapping. Color reddish-brown above, yellow below. Weight usually to 200 kg.
Caretta caretta (loggerhead).....Figure 6

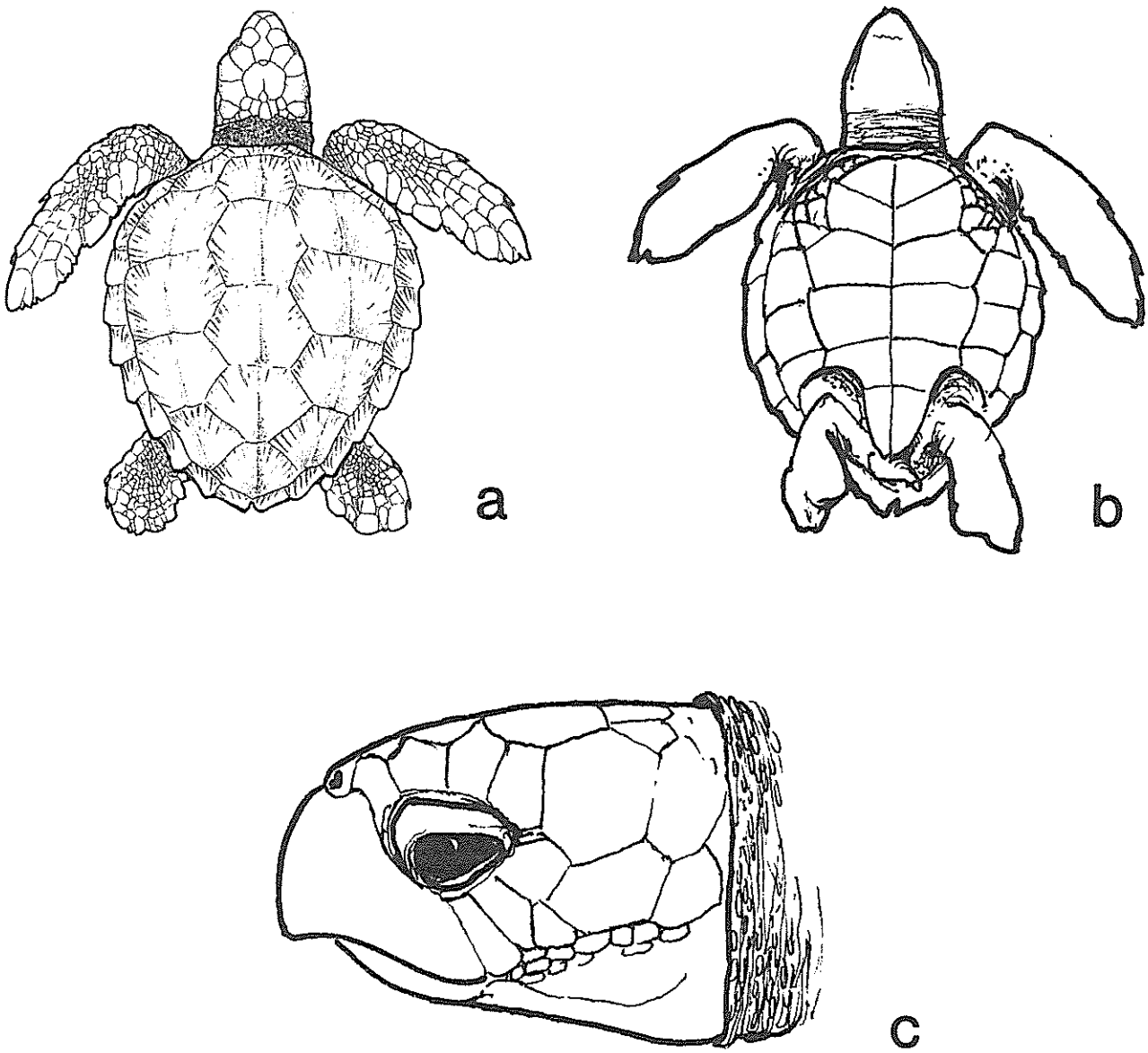


Figure 6. *Caretta caretta* (loggerhead); 6,a: dorsal view; 6,b: ventral view; 6,c: head view.

e) Four pairs of lateral scutes. Head, to 15 cm wide. Carapace, to 125 cm long. One pair of prefrontal scales. Four postorbital scales. Carapace scutes do not overlap. Color varies from light tan to almost black above, often with radiant or spotted markings, underside yellow. Weight to 230 kg.
Chelonia mydas (green turtle).....Figure 7

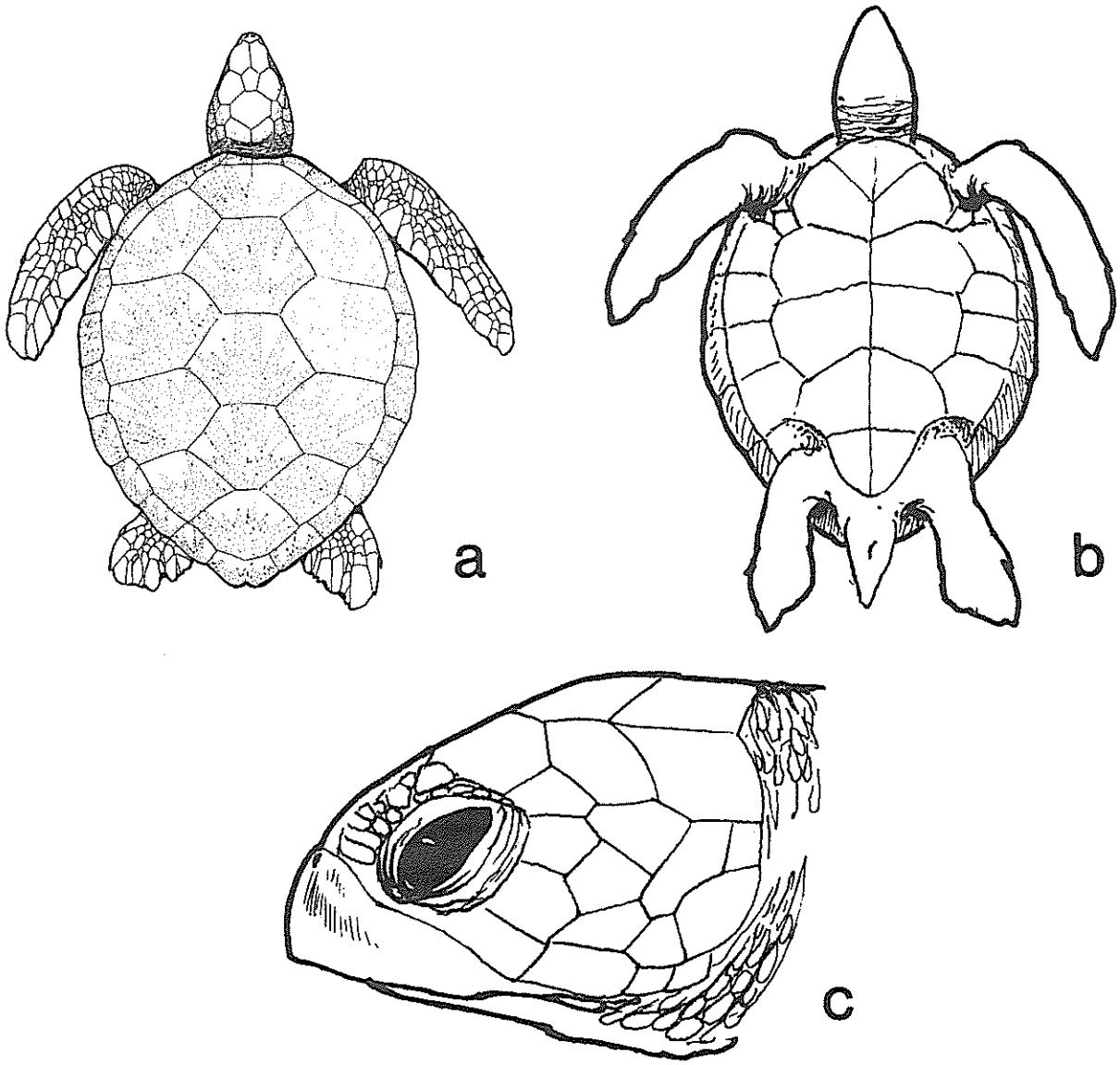


Figure 7. *Chelonia mydas* (green turtle); 7,a: dorsal view; 7,b: ventral view; 7,c: head view.

f) Four pairs of lateral scutes. Head, to about 12 cm wide. Carapace, to 100 cm long. One pair of prefrontal scales. Four postorbital scales. Carapace scutes do not overlap. Color generally dark, sometimes black without light edges on head scales, underside whitish with variable grey to fuscous, often dense. Weight to 100 kg.
Chelonia agassizi (black turtle).....Not illustrated

g) Four pairs of lateral scutes. Head, to about 13 cm wide. Carapace, to 100 cm long. One pair of prefrontal scales. Three postorbital scales. Carapace scutes do not overlap, very thin, with indistinct margins, especially in adults. Dorsal color yellow-grey to grey-green, without spots or radiating markings; underside light yellow. Weight to 90 kg.

Chelonia depressa (flatback).....Figure 8

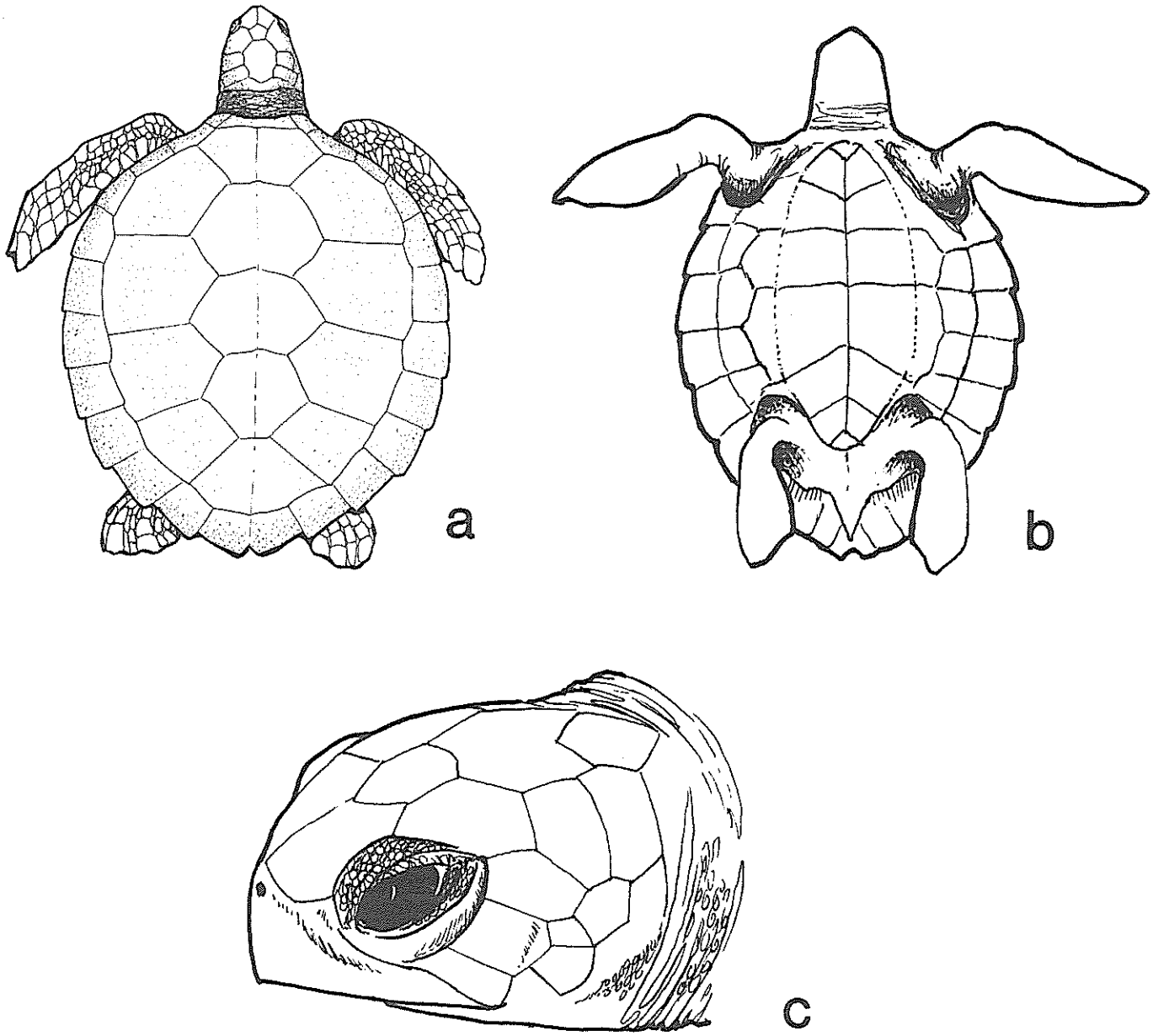


Figure 8. *Chelonia depressa* (flatback); 8,a: dorsal view; 8,b: ventral view; 8,c: head view.

h) Carapace with seven (rarely five) longitudinal ridges, no scutes. Head, to 25 cm wide. Carapace, to about 190 cm long. Head and flippers covered with unscaled skin. Dorsal coloration predominantly black, with variable degrees of white spotting. Spots may be bluish or pink on neck and base of flippers. Underside similar but with light rather than dark areas. Weight to 600 kg.
Dermochelys coriacea (leatherback).....Figure 9

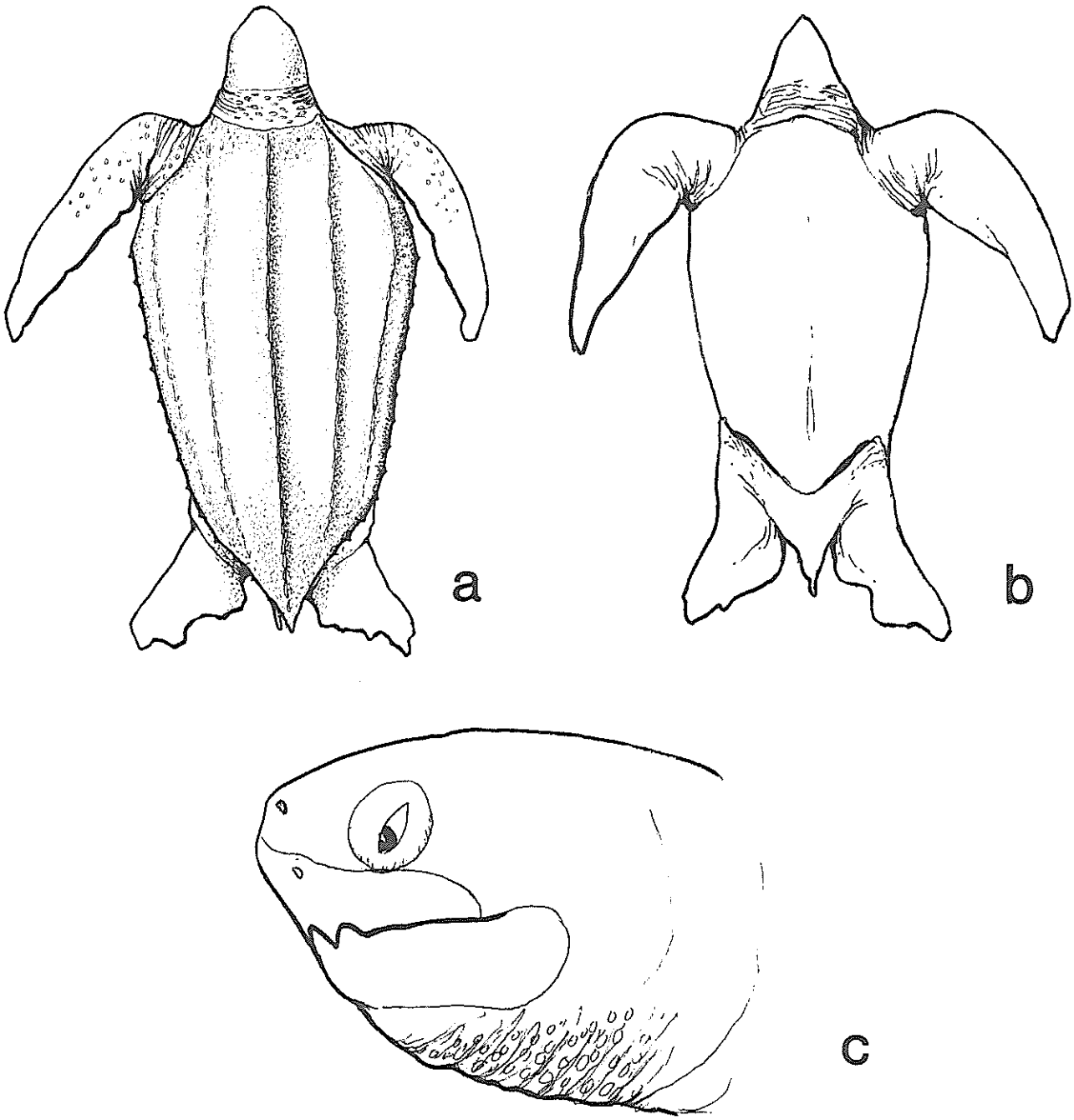


Figure 9. *Dermochelys coriacea* (leatherback), 9,a: dorsal view; 9,b: ventral view; 9,c: head view.

C.1.3 Identification of Hatchlings

For reasons still somewhat obscure, hatchling turtles are rarely seen when they are at sea. They may be found, however, on nesting beaches. Sometimes they are blown onto other beaches by storms. The young turtles usually dig out of the nest at night, emerging nearly simultaneously on the sand's surface and proceed rapidly to the sea. But some die on the beach (killed by birds, exposure to sun, etc.). Therefore, surveyors who visit a nesting beach during the day in season may be able to collect specimens of dead hatchlings and identify the species.

Hatchling turtles may be identified according to instructions for identification of a turtle in hand, because hatchlings' scale and scute counts match those of adults (though with perhaps a higher percentage of abnormal variations than the adult pattern). In addition to Color Plates 1-32, Annex I, the following points will assist in hatchling identification:

I. Hatchling ridleys of both species are very dark grey or black both above and below. They may be differentiated from each other only by the lateral scute count (five pairs in *L. kempi*, usually six to eight or nine pairs in *L. olivacea*).

II. Hatchling loggerheads and hawksbills are both brown above and below (shade varying from light to dark). The two species look very similar as hatchlings, but may be differentiated by the lateral scute count (five pairs in *Caretta*, four pairs in *Eretmochelys*).

III. Hatchlings of the three species of *Chelonia* are the only ones with a white plastron. Hatchling *C. depressa* is substantially larger than hatchling *C. mydas* and *agassizi*, has an oval rather than posteriorly tapering carapace, turquoise rather than black eyes, three rather than four scales behind each eye (postorbital scales), and a yellow rather than grey band around the underside of the marginals.

IV. Hatchling leatherbacks are unmistakable. The longitudinal shell ridges are already present, the fore flippers are extremely long (almost as long as the carapace), and the entire skin of the animal, shell and soft parts is covered with small, soft, polygonal scales.

C.1.4 Identification of Tracks and Nests

Two typical sea turtle nesting positions are illustrated in Figure 10. The deep body pit shown on the right side of Figure 10 is characteristic of green turtles and leatherbacks. Loggerheads, hawksbills, ridleys and flatbacks dig little or no body pit, as shown on the left. The leatherback will often fill the body pit completely after nesting, leaving a large area of disturbed sand.

Figure 10. Two typical nesting positions of sea turtles, showing the differences in depth of body pits.

Other reptiles, notably iguanas and crocodiles, may occasionally nest in ocean beaches, and one species of emydid turtle (*Callagur borneoensis*) nests on ocean beaches in South-East Asia. These animals all leave considerably narrower tracks on the beach and there is usually no problem distinguishing the nests from those of sea turtles. If necessary, eggs can be exposed and will be seen to be far fewer than those of sea turtles and generally elongate in form rather than spherical.

C.1.4.1 Species Track and Nest Descriptions

Different kinds of sea turtle nesting tracks are diagrammed in Figure 11.

a. **Kemp's ridley** (***Lepidochelys kempi***)

Track width: typically about 80 cm.

Type of track: very shallow, with alternating (asymmetrical) diagonal marks made by the front flippers. Usually obliterated because nesting takes place during high winds. Nests in daytime.

Preferred beach type: nests exclusively in the western Gulf of Mexico, with almost all nesting concentrated on a few miles of beach in southern Tamaulipas State (Rancho Nuevo), where the beach is continuous for hundreds of miles; moderate energy, low tidal amplitude, with well-vegetated dunes and associated marshes.

Number and size of eggs: clutch size averages about 105 eggs. Egg diameter typically 4 cm.

Geographic location of nesting beaches: see above ("Preferred beach type").

b. **Olive ridley** (***Lepidochelys olivacea***)

Track width: typically about 80 cm.

Type of track: very shallow, with alternating (asymmetrical) diagonal marks made by the front flippers. Nests at night except during massive *arribadas* when nesting also may occur in daylight hours.

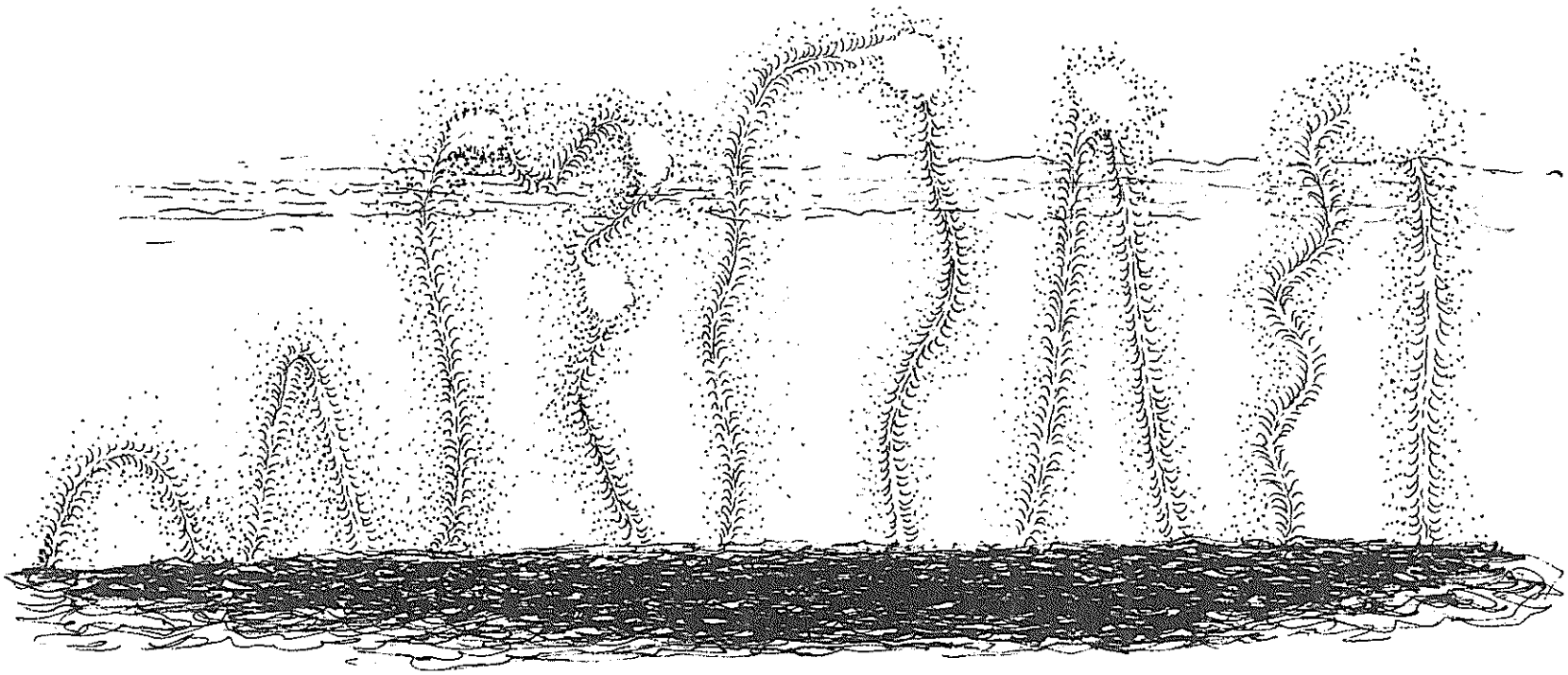


Figure 11. Various types of sea turtle crawl tracks and nest marks to be seen on sandy beaches.

Preferred beach type: variable; almost always on mainland tropical shores with lightly vegetated or unvegetated berm areas.

Number and size of eggs: clutch size averages about 100 eggs. Egg diameter typically 4 cm.

Geographic location of nesting beaches: mainland tropical shores of Pacific, Indian and South Atlantic oceans, with high concentrations in certain limited areas on Pacific coasts of Mexico and Costa Rica, also Suriname and India. No nesting known outside tropics or on oceanic islands.

c. **Hawksbill (*Eretmochelys imbricata*)**

Track width: typically about 75 to 80 cm.

Type of track: shallow, with alternating (asymmetrical), diagonal marks made by the front flippers.

Preferred beach type: exclusively tropical, often nesting on small beaches on coral islands where no other species is known to nest; also nests on beaches on granitic islands (Seychelles) and limestone islands (Mona). However, small numbers may nest on large mainland beaches heavily used by other species. Nests and tracks are hard to distinguish from those of ridleys, but the two generally have different beach-type preferences and rarely nest together. Also, hawksbills frequently nest under overhanging vegetation, unlike ridleys which usually nest in open areas. Hawksbills often wander extensively before nesting.

Number and size of eggs: clutch size variable, often high; known range 53 to 250 eggs, average 161 in Caribbean, 182 in Seychelles. Egg diameter typically 4 cm.

Geographic location of nesting beaches: tropical shorelines of Atlantic, Pacific, and Indian oceans.

d. **Loggerhead (*Caretta caretta*)**

Track width: 90 to 100 cm.

Type track: moderately deeply cut, with alternating (asymmetrical) diagonal marks made by the front flippers.

Preferred beach type: generally extensive mainland beaches and barrier islands; moderately steep beach profile preferred.

Number and size of eggs: average clutch approximately 120 eggs. Egg diameter typically 4 cm.

Geographic location of nesting beaches: subtropical sites preferred, e.g., southeastern United States (Atlantic, more than Gulf coasts); southern Brazil; Japan; South Africa; temperate Australia. However, some tropical nesting areas are known,

including Pacific Panama and Caribbean Colombia. Rarely, if ever, nests on oceanic islands.

e. **Green turtle (*Chelonia mydas*)**

Track width: typically about 1 m.

Type of track: deeply cut, with symmetrical diagonal marks made by the front flippers.

Preferred beach type: generally large, open beaches, but exceptions are known (e.g., on Ascension Island, beaches in small coves are used).

Number and size of eggs: clutch size very variable averaging 111 eggs for the Tortuguero, Costa Rica, colony, and sometimes more than 200 in the Atlantic (Suriname, Ascension Island). Egg diameter typically 5 cm.

Geographic location of nesting beaches: large colonies may nest both on mainland beaches or remote oceanic islands. Tropical beaches preferred; northern limit of regular nesting is Florida and northern Mediterranean in the Atlantic area.

f. **Black turtle (*Chelonia agassizi*)**

Track width: typically about 90 cm.

Type of track: as for green turtle but less deeply cut.

Preferred beach type: wide, not steeply shelving, often enclosed between rocky headlands.

Number and size of eggs: usually 80 or fewer, typically 4.5 cm in diameter.

Geographic location of nesting beaches: eastern Pacific, both mainland (Mexico, Costa Rica) and islands (Galapagos and Revillagigedos).

g. **Flatback (*Chelonia depressa*)**

Track width: about 90 cm.

Type of track: relatively lightly cut, with symmetrical diagonal marks made by the front flippers.

Preferred beach type: fairly large open beaches, on mainland or large islands; reef habitat avoided.

Number and size of eggs: average clutch only about 50 eggs (maximum 73). Eggs typically 5.5 cm in diameter.

Geographic location of nesting beaches: Australia.

h. **Leatherback** (*Dermochelys coriacea*)

Track width: 1.5 to 2 m.

Type of track: very deep and broad, with symmetrical diagonal marks made by the front flippers usually with a deep incised median groove formed by dragging the relatively long tail.

Preferred beach type: large, long, tropical beaches with a considerable slope and unobstructed deep water approach.

Number and size of eggs: clutch size averages about 85 eggs, usually less than 120, not including a variable number of yolkless undersized eggs found in every nest. Full-size eggs 6 to 6.5 cm in diameter.

Geographic location of nesting beaches: nests usually in colonies on isolated mainland beaches in all tropical oceans. Rarely nests outside tropics or on islands, although nesting is known in the Caribbean on many of the Greater and Lesser Antilles (e.g., St. Croix).

C.1.4.2 The Age of the Track: Fresh Crawls and Old Crawls

For survey purposes, it is desirable to distinguish between fresh crawls and old crawls. A fresh crawl is defined as one made within 24 hours of the survey. An old crawl is one made more than 24 hours previously.

If a survey is made early in the morning, fresh tracks made the previous night are often identifiable as such. The marks are crisp and clear and extend to the surf-line. The first high tide or heavy rainfall after nesting, or the nesting of later turtles, will obscure the lower part of the tracks. Knowing the time of high tides or of recent rain can help in estimating the age of tracks. Wind gradually obscures tracks and nest sites on the upper, drier parts of the beach, so that old marks have less sharp edges and generally disappear altogether.

C.1.4.3 Whether Nesting was Successful: Nesting Crawls and False Crawls

Usually a sea turtle crawl is a nesting crawl - one that results in digging a nest and laying eggs. But sometimes a sea turtle crawls without nesting. This is a "false crawl." To survey and monitor nesting success, it is important to distinguish between nesting crawls and false crawls (see Figure 11). Turtles will sometimes dig a nest and subsequently cover it without having laid eggs.

C.1.5 Species Identification Problems

Individual turtles may prove difficult to identify for any of the following reasons.

C.1.5.1 Epizootic Organisms

Barnacles or other attached organisms may hide features critical for identification. Loggerhead and hawksbill turtles, especially old ones, are most likely to be heavily infested with barnacles and other adhering organisms. Ridleys of both species are never heavily fouled with barnacles, etc., although many adults do carry isolated barnacles on the shell and sometimes the top of the head. Leatherbacks in the Atlantic are free of barnacles, though in the East Pacific moderately heavy barnacle encrustation has been recorded. Typically free of large barnacles, green turtles are quite clean, although occasionally, especially in protected lagoons, a few are found with moderate to heavy barnacle accretion. The black turtle may be heavily encrusted with barnacles and coralline algae. Flatback turtles carry few barnacles.

Even badly fouled turtles can be identified on the basis of overall size, shape, relative head size, etc. Surveyors can distinguish a heavily encrusted loggerhead from a hawksbill, for instance, because it has a much wider head. And the hawksbill's overlapping scutes are seldom totally obscured by barnacles.

C.1.5.2 Scute and Scale Count Deviations

All turtle species show a certain frequency of deviations from the standard scute and scale counts given in the identification guide (C.1.2). The scute counts of the olive ridley are so variable that there is no typical pattern for this species. Lateral scute counts cited for the other species characterize the vast majority of individuals. It is not uncommon, however, for variations to occur. For example, any of the hard-shelled turtles may show a small extra central scute between the fourth and fifth centrals; occasional green turtle and hawksbill specimens may have more than four laterals on each side. Even in such cases, the extra scutes seldom take the form of the additional lateral scutes that is normal for the loggerheads and ridleys. In the ridleys, the first lateral is relatively small, followed by four much larger scutes which diminish posteriorly. Rare loggerhead specimens missing the small first lateral scutes may be more confusing. However, such specimens still show typical characteristics of color, body shape and proportions, and can be identified with a little experience.

Specimens that, after exhaustive study, appear not to be clearly referable to any single species should either be retained if dead, or photographed from all angles in close detail for subsequent study by an expert before release. Individuals encountering such specimens should be aware of the possibility of domestic permit requirements for handling, keeping or preserving sea turtles.

C.1.5.3 Other Turtle Species

Some turtles found in a marine or estuarine environment are not true sea turtles; several species of freshwater (river or marsh) turtles may enter the sea by accident. Also, salt or brackish waters are the

normal habitat of certain freshwater species during part of their life cycle.

Generally, sea turtles can be distinguished from freshwater species by their forelimbs. True sea turtles have flattened fore flippers in which the individual digits are obscured and show no independent movement. They usually have a single claw on the foremargin on each front flipper; a second claw, if present, is very small. The leatherback has no claws.

Most freshwater turtles have five claws on each forelimb or "foot," with the individual digits easily distinguishable, even if partly or fully webbed. Soft-shelled turtles' forelimbs are part-way between "feet" and "flippers," but the three claws on each foot are well-defined.

Some of these freshwater species are not well known, especially in tropical regions. Therefore, recording their presence during sea turtle surveys is useful. Some freshwater species found from time to time in the marine environment are:

1. *Malaclemys terrapin* (diamondback terrapin). Range: U.S.A. Atlantic and Gulf Coast from Cape Cod to southern Texas. Maxiumum size about 20 cm.

2. *Pseudemys concinna suwanniensis* (Suwannee turtle). Range: U.S.A. Gulf drainage of Florida from Tampa area to Western Florida, most abundant in the Suwannee River itself. Size: Females up to 43 cm carapace length, males about 33 cm.

3. *Podocnemis expansa* (Orinoco River turtle, arrau turtle). Range: Orinoco and Amazon River systems of South America. Regularly carried to Trinidad by the Orinoco in flood. Size: Adult females average about 66 cm, maximum about 80 cm.

4. *Trionyx triunguis* (Nile soft-shelled turtle). Range: Nile drainage, much of Africa, parts of the eastern Mediterranean countries. Only known to enter the marine environment in eastern Mediterranean. Apparently a normal part of the marine fauna off Turkish coast. Size: Carapace length up to about 80 cm.

5. *Pelochelys bibroni* (giant soft-shelled turtle). Range: From the Malaysian Peninsula and Thailand, through Indonesia and the Philippines, to New Guinea. Size: Reputed to reach 160 cm carapace length; usually much smaller, but specimens over 70 cm are common.

6. *Carettochelys insculpta* (plateless river turtle). Range: Fly River and associated drainages in southern New Guinea; Daly River and a few other rivers in the Northern Territory, Australia. Found on occasion in the Arafura Sea and the Gulf of Carpentaria. Size: Carapace length up to 50 cm.

7. *Callagur borneoensis* and *Batagur baska* (Asiatic river turtles, "tuntong sungai" and "tuntong laut"). These two rather similar

species are often confused, though the coloration in breeding season, especially of males, is distinct. Range: Southern Thailand, Peninsular Malaysia, Borneo (only *Callagur*) and Sumatra. Size: Females of both species are commonly 60 cm in length; males are smaller, 30-35 cm.

C.1.5.4 Possible Hybridization

It may be possible for sea turtle species to hybridize.

C.2 Aerial Surveys

Two kinds of sea turtle aerial surveys are described in this section. Aerial beach surveys are flown along shorelines to record sea turtle crawls on the beaches. Pelagic aerial surveys are flown over the water to record sea turtles at the surface.

Aerial surveys are the fastest and sometimes the most cost-effective way to document potential or active turtle nesting beaches and to obtain data on sea turtle populations, distribution, and activities over an extensive area. However, because the techniques of neither aerial beach surveys nor pelagic aerial surveys have been perfected, results must be carefully interpreted, and qualified. Moreover, surveyors must take care to record their observations in a standarized format so that data from different times and areas are as compatible as possible for comparison, integration and analysis. Several recommended survey procedures are described below based upon the type of information needed, and upon the kind of survey possible.

C.2.1 Aerial Beach Survey

The primary objective of an aerial beach survey is to record the number of sea turtle crawls (tracks) made along the beach by female sea turtles nesting or attempting to nest.

Three types of aerial beach surveys are described, each serving a specific purpose: 1) to determine areas of turtle usage that were not previously known or have not been recorded in recent years; 2) to determine relative nesting densities over an area or nesting season; and 3) to provide data necessary for estimating an area's sea turtle population of nesting females. Each type of survey requires a different intensity of effort and technique, and these will be delineated below.

For the first type of survey (to determine turtle usage), a single survey with one or two observers may be adequate or all that is possible. Covering as much shoreline distance as possible at the estimated peak of the nesting season for a particular species would be the objective of this initial survey.

For the second type of survey, multiple flights at selected intervals over a known area of nesting beaches can bracket the nesting season and give relative nesting densities.

The third type of aerial beach survey (to estimate population size for a specific area of beach or shoreline) requires a more structured technique and more effort. Repetitive flights bracketing and during the nesting season must record the number of sea turtle nesting crawls within defined shoreline zones. In addition, ground truth surveys (C.2.2) must be made over selected zones or marked portions of zones during the night before or (preferably) on the morning of the aerial survey.

Because aerial observers cannot count crawls, or determine nesting crawls from false crawls, or identify the species making the crawls, as accurately as observers walking or riding on the beach (especially in areas of concentrated crawls), ground truth survey records are necessary to compare with, indicate errors in, and provide correction factors for aerial survey records.

Ground truth surveys are desirable for the first two types of surveys, especially where the species nesting is (are) uncertain or unknown, but are not mandatory.

In addition to the three purposes defined above, aerial beach surveys can and should also record, if possible: sea turtle carcasses, nest predator activity, factors that may interfere with sea turtle nesting, hatchling emergences, and sea turtle activity in nearshore waters; also the nature of the shoreline and activity along it; and marine mammals sighted, fish concentrations, and fishing activities.

C.2.1.1 Aircraft

A wing-over cockpit, single engine, four-seat aircraft is recommended for aerial beach survey, because it is the most versatile for all survey types. Two or three-seat aircraft may suffice. Six-seat, twin engine aircraft are more expensive to operate, and their stall speed may be too fast on surveys for population estimates. However, they afford an extra degree of safety when extensive flying over water is necessary, and they are acceptable for the first type of survey. Helicopters are especially useful in high density nesting areas where the slowest speeds are needed. They also have the added capability of hovering to better examine disputed crawls and landing in small areas to document stranded carcasses. They are, however, more expensive.

C.2.1.2 Considerations for Aircraft Charter

A trained, capable pilot is important for a successful survey. The following suggestions may eliminate some problems when a plane and pilot are chartered for the first time.

Before the flight, determine the flying time, the plane's fuel capacity and survey costs. Check the pilot's safety record and flying ability. He or she should be able to maintain the plane's position and inform the recorder of their location relative to the charts. Determine the flight path, the plane's speed capability (slowest and cruising), its minimum altitude, and any inflight restrictions created by altitude,

or the height and distances off all shorelines. Investigate local weather and aerial conditions such as updrafts that might interfere with the survey. Consult pilot about overwater flight conditions when surveying offshore islands. Determine possible landing strips along the route, and obtain prior authorization to enter any restricted areas that the survey zone might encounter. Emergency gear, life preservers, and emergency procedures should be explained to the crew. An intercom system may be useful.

C.2.1.3 Personnel

Four persons are ideal: a pilot, two observers and a recorder. The pilot usually sits left-front and continually informs observers/recorders of location, landmarks, time, weather conditions, and changes in speed or altitude.

The two observers sit right-front and right-rear. They should make independent observations and counts and both sets of observers' sightings should be recorded to evaluate bias. However, on initial or infrequent flights, especially with inexperienced observers, surveyors should compare and confirm observations as they occur.

The recorder sits left-rear, records all events the observers and pilot report, and watches, when possible, for sea turtle activity in the water on the left. With only three persons, the recorder sits right-rear and assists in observations whenever possible. With only two persons, the observer sits at right-front and doubles as recorder.

Training and experience are most important. As serial surveys proceed, observer reliability should be assessed and factored into the results.

C.2.1.4 Equipment and Supplies

Necessary equipment and supplies are minimal. Data recording forms are discussed below. For surveys of unfamiliar areas, observers and recorders need a standard set of maps, with shoreline zones and landmarks previously determined whenever possible. The maps should be cut or folded and arranged to facilitate easy in-flight reference. Personnel should be familiar with the maps and landmarks before the survey flight begins. Where turtle crawls are abundant, each observer should use a hand-held, digital, event counter. At each landmark, the recorder should take the used counter from the observer, record the tally and provide the observer with a fresh counter. Or, a reliable hand-held tape recorder may be used, especially when no second person is available as data recorder. The tape recorder should be tested before take-off and several times in flight to be sure the replay can be understood over cabin noise. Watches should be synchronized before departure.

C.2.1.5 Time of Survey

The best time to survey a beach from the air is early morning unless shadows from vegetation obscure visibility. Observers can see tracks most clearly from the time the sun first strikes the beach until about 0900 hours EST. After that, the higher angle of the sun frequently makes observations of the beach more difficult. Light colored sand beaches become too bright for accurate counting and the shadows cast by the turtle tracks lessen, making the tracks less conspicuous. Track depressions in the dry sand become less visible, so fresh tracks are harder to discern.

As the sun begins to set in late afternoon, or when it no longer directly strikes the beach, the tracks become visible again. The survey can be resumed then, although afternoon conditions are seldom as good as those in early morning because of weathering of the tracks and human activity on the beach obliterating the tracks.

C.2.1.6 Weather and Tides

Day-to-day knowledge of ocean tides and weather conditions should be maintained throughout the survey period. Knowing when the tides occur and the approximate time of the most recent rainfall can help in interpreting the age of crawls being counted.

Rainfall may eliminate some crawls on some beaches and may "age" other crawls. Rainfall on the beaches during the night or morning prior to the survey flight may cause some fresh crawls to appear as old crawls.

Tides, under certain circumstances, can be used to positively determine fresh crawls from old crawls. The circumstances are described below.

When high tide occurs in the early morning, between about 0200 hours and dawn, almost all of the crawls in the intertidal zone from the previous night will be erased. In this circumstance, tides cannot be used to determine fresh crawls. When high tide occurs about midnight, the crawl portions in the intertidal zones will remain for sea turtles that crawled after midnight, but will be erased for those that crawled between dark and midnight. This will cause uncertainties in aging crawls, if one of the major purposes of the flight is to count only "fresh" crawls, i.e., those made the previous night. When high tide occurs soon after dark, and when the high tide interval is about 12 hours, and when the night (dark) period is about 8 hours, then fresh tracks will be identifiable in the intertidal zone for about three hours after dawn.

Therefore, to obtain maximum fresh crawl counts of greatest reliability (as is the need of intensive surveys for population estimates), the date of flights should be selected when high tide occurs soon after dark and when flights are completed in the early morning. For example, where most or all crawls are made after 2000 hours EST and when high

tide occurs at 2000 hours EST (with a 12-hour high tide interval), the fresh crawls will be impressed in the intertidal zone and identifiable as such until about 0800 or 0900 EST. An aerial beach survey, or a ground truth survey, conducted between dawn and about 0900 hours EST can then reliably determine all fresh crawls. These times are appropriate for the southeastern U.S. during the summer months. In more southern regions or at different seasons, the times will have to conform with the local sunset and tidal stage.

C.2.1.7 Speed, Altitude, and Distance off Shoreline

These survey flight characteristics are interrelated. The general guidelines are:

a. For routine beach surveys, fly at 80 knots (75 to 85 knots, if this is a safe speed for the aircraft), at an altitude of 150-200 feet, and at a distance offshore that forms about a 45 degree angle to the water line (about 150-200 feet offshore). Fly over the lower portion of the beach if identification of body pits is part of the survey.

b. For beaches with dense sea turtle crawls (or with gusty winds), fly at 300 feet altitude, and resurvey the area, time permitting, if first observations are uncertain.

c. For shorelines without beaches or where turtle crawls are very rare, fly faster (110-130 knots) and at about 400 feet altitude.

d. When flying over water for a few miles or more during a shoreline survey, fly at 500 feet altitude and 110-120 knots and record any turtles seen (as in Pelagic Aerial Survey, C.2.4).

C.2.1.8 Maps and Charts

No optimum and comprehensive set of charts exists for the shorelines of the entire western Atlantic area. For surveying areas new to the survey team, the advice is to get the best charts available before the survey period begins. Generally, two scales of a chart series are useful--a large-scale chart to determine landmarks which separate zones and to measure shoreline distance and a small-scale chart for plotting position in the aircraft during the survey.

When a beach aerial survey is being flown along a shoreline of an area (country, state or other unit) that has not been documented previously, geographic features (such as cliffs or sand beaches) should be recorded. This will allow flight paths for later surveys to be planned more efficiently.

Topographic charts are very useful. Those from the U.S. Army Topographic Command (Washington, D.C. 20315) are published for many areas; the useful scales are 1:500,000 and 1:250,000. Charts from the U.S. Department of Commerce, National Oceanic and Atmospheric

Administration, are available for most areas; a scale of about 1:500,000 may be useful for in-flight recording, but larger-scale charts should be used for selecting landmarks. World Aeronautical Charts (from above source) may be used. Road maps, issued by some oil companies, have been successfully used in some surveys.

The primary map used should be marked with appropriate and useful landmarks (towns, roads, bridges, and other features).

C.2.1.9 Aerial Survey Zones

Before starting an aerial survey, each country, state or other geographical region should be divided into standardized zones, numbered serially beginning with 001. These zones may be from one to forty km long, depending on the density of known nesting or on the uniformity or variability of the coast. The zone borders should be based on permanent landmarks. All landmarks not shown on the primary, large-scale map should be described in relation to points which appear on this map. The aerial survey zones should be the same for the ground truth survey, except that the latter may be sub-divided into smaller units that can be patrolled in a reasonable time on foot or by vehicle.

C.2.1.10 Data Recording Forms for Aerial Beach Surveys

Form 1 is designed to facilitate: 1) a comprehensive compatible comparison of shorelines (and sea turtle nesting activity) throughout the western Atlantic area; 2) comparisons of data from different survey areas, periods, and recorders; and 3) computer entry of data without excessive transcription. Zone records should be completed on an initial survey and before actual crawl count surveys are begun. Form 1A is an example of how this form should be filled in.

Form 1 Explanation

a. Country and State. Write these in. They will be computer-coded in subsequent analysis of the entire area.

b. Date(s). Of form preparation or when the flight(s) was made.

c. Chart(s) Used. Give source, number, scale.

d. Observer(s). List names of all involved in formulating this form.

e. Recorder(s). List names of people filling out form.

f. Heading(s). Give from start to end in approximate degrees or positions. In circling an island, headings will be inclusive.

g. Zone Name or Number. Each row represents one zone, unless a second or third row is needed and duplicated in the first column. If using number, start with 001 and number consecutively for each country, state or other area.

FORM 1.

Sea Turtle Aerial Beach Survey

Form 1: ZONE RECORDS

Page____of_______

Country______________________________State______________________Date(s)________________

Chart(s) Used____

Observer(s)____Heading(s)__________________

Recorder(s)____

Zone Name or Number	Zone Landmarks		Distance KM-NM	Lat.	Long.	Zone Heading	Shoreline Characters
	Start	End					

FORM 1A

Sea Turtle Aerial Beach Survey

Form 1: ZONE RECORDS

Country USA State South Carolina Date(s) 800609

Chart(s) Used USGS 1:250,000

Observer(s) T. Murphy, S. Hopkins Heading(s) N → S

Recorder(s) S. Hopkins

Zone Name or Number	Zone Landmarks Start	Zone Landmarks End	Distance KM-NM	Lat.	Long.	Zone Heading	Shoreline Characters
Huntington B. S01	Murrells Inlet	first house	6.5	33°50'	79°04'	SSW	wide flat beach, State park campsites near beach
Litchfield S02	first house	Midway Inlet	6.4	33°30'	79°04'	SSW	single family homes good dunes
Pawleys Is. S03	Midway Inlet	Pawleys Inlet	5.2	33°25'	79°07'	SSW	single family homes dunes eroding
Debidue Is. S04	Pawleys Inlet	North Inlet	7.1	33°22'	79°09'	SSW	low development seawall in mid portion of island
North Is. S05	North Inlet	Winyah Bay	13.5	33°16'	79°10'	S	high energy beach, no devel.
Sand Is. S06	Winyah Bay	inlet	4.0	33°11'	79°11'	SW	low profile beach many washover terraces
South Is. S07	inlet	N. Santee Riv.	4.0	33°09'	79°13'	SW	no devel. erosion in mid portion
Cedar Is. S08	N. Santee Riv.	S. Santee Riv.	4.3	33°07'	79°15'	S	erosion in mid portion South end good dunes
etc.							

h. Zone Landmarks. The name of a permanent physical feature (either natural or man-made) easily seen from the air is written in the "start column." When zones are continuous, the landmark at the "end" of one zone will be the "starting" landmark for the next zone. When areas are discontinuous, the new landmark is written in the next row and the zone name or number is repeated.

i. Distance KM-NM. This is the shoreline distance of the zone (measured, calculated, or estimated). The distance can be readily calculated by using a rotating map measurer on a large-scale chart. The recording unit used, kilometer (KM) or nautical mile (NM), is circled.

j. Lat. Long. The latitude and longitude in degrees and minutes (to the nearest tenth minute) are calculated from a chart and recorded for the start of the zone.

l. Shoreline Characteristics. This is a synopsis of the characteristics of the shoreline that occur in each zone. See section C.2.1.11 for descriptions. Where more than one type of shoreline occurs along a zone, either record the dominant type or give the different types in estimated percentages. However, the primary purpose of this survey is to document active or potential sea turtle nesting beaches, so the presence and relative amount of any high-energy or low-energy sand beaches should always be recorded in each zone.

Forms 2 and 3 (Flight Data Records) are similar but are designed for different types of surveys and to provide for different informational needs. Both forms have the same format at the top of the page.

Form 2 is recommended for any of the following conditions: a) on surveys flown by observers with limited survey experience; b) where crawls may not be relatively numerous; c) where the researcher desires to more precisely map the relative location of the crawls. On Form 2 the column labeled "time" is in hours, minutes, and seconds. By recording the time in seconds and then computing airspeed and distance traveled from zone boundaries, the location of the tracks can be precisely mapped. On Form 2, the start time should be recorded for each zone and the end time recorded for the final zone. See Form 2A for a completed version.

Form 3 is to be used for recording the total number of each type of crawl. Numbers from each observers would be recorded on this form from the digital event recorders or transcribed from the tape recorders. Form 3 is recommended in high density nesting areas and where mapping the location of crawls other than by zone or general location is not necessary. See Form 3A for a completed version.

Forms 2 and 3 Explanation

a. Flight #. Number flights consecutively if multiple flights.

b. Country and State. Enter name(s). Code numbers will be assigned later.

FORM 2

SEA TURTLE AERIAL BEACH SURVEY

Form 2: FLIGHT DATA RECORDS

Page_____ of____

Flight #:_________ COUNTRY____________________ State_______________ Zones ____________ DATE_______________

Observer 1________________ Observer 2________________ Recorder________________ Pilot________________

Aircraft________________ Time: S________ F________ Speed_________ Altitude_________

Weather: Current___________ Prior 24 Hrs.___________ Tidal State___________ Sea State___________

Ground Truth Survey Made____________________ Zone Record on File__________________

ZONE	TIME			NUMBER OF CRAWLS											
				FRESH			OLD			Age Uncertain					
Number/Name	Hour	Min.	Sec.	Nest	False	Unk	Nest	False	Unk	Nest	False	Unk	Total	Species	Other Data

FORM 2A

SEA TURTLE AERIAL BEACH SURVEY

Form 2: FLIGHT DATA RECORDS

Flight #: _____ COUNTRY COSTA RICA State CARIBBEAN Zones 1-21 DATE 83 03 18

Observer 1 F.H. BERRY Observer 2 R.R. LANKFORD Recorder F.H. BERRY Pilot N. BROWN

Aircraft CESSNA 206 Time: S 0618 F 1142 Speed 95-100 KT Altitude 150-200 FT

Weather: Current 0 Prior 24 Hrs. ? Tidal State 9 Sea State 01

Ground Truth Survey Made Only 5 crawls at Tortuguero airstrip Zone Record on File ?

ZONE Number/Name	TIME Hour	Min.	Sec.	NUMBER OF CRAWLS FRESH Nest	FRESH False	FRESH Unk.	OLD Nest	OLD False	OLD Unk	Age Uncertain Nest	Age Uncertain False	Age Uncertain Unk	Total	Species	Other Data
LV. TOBIAS BOLANDS ARPT.	06	18	—												
START ZONE 1 NICARAGUA BORDER	06	57	—												
— BOCA RIO SAN JUAN	07	00	20												
		02	04									?			Circle
		03	35								Negative				"
2 BOCA COLORADO		04	53												
		06	40									1		Dc	Circle
		08	20						Confirm track						"
		09	57						1					Dc	
		10	43						1					Dc	
		10	57			1								Dc	
		11	50						1					Dc	
		13	51						1					Dc	
		14	16			1								Dc	
END ZONE 2		14	42												
	07	20	—	Break-off Survey. Land @ Tortuguero Airstrip/Ground Truth Survey											
LV. Tortuguero	09	33													
START 3 BOCA DEL TORTUGUERO	09	35	50												
		35	51							1				Dc	
		36	14							3				Dc	
			14							1				Ei	
			18							1				Dc	
			31							1				Dc	
			59							2				Ei	
		37	21							1				Dc	
			55							1				UK	
		38	48							1				Dc	
			50							1				Dc	
		39	06							1				Dc	
			06								2			Dc	
			11							1				Dc	

FORM 3.

Sea Turtle Aerial Beach Survey

Form 3: FLIGHT DATA RECORDS

Page_______ of _______

Flight#: __________ Country __________ State __________ Date __________

Observer 1 __________ Observer 2 __________ Recorder __________ Pilot __________

Aircraft __________ Time: S _____ F _____ Speed _____ Altitude _____ Weather: Current __________

Previous 24 Hours __________ Tidal State __________ Sea State __________

Ground Truth Survey Made __________ Zone Record on File __________

Zone	Time		Observer #1						Observer #2						Other Data
			Fresh						Fresh						(Stranding
Name or Number	Start	End	Nest	False	Unk.	Old	Total	Species	Nest	False	Unk.	Old	Total	Species	Boats,etc.

FORM 3 A

Sea Turtle Aerial Beach Survey

Form 3: FLIGHT DATA RECORDS

Page 1 of 2

Flight#: 3 Country USA State South Carolina Date 810620

Observer 1 T. Murphy (RF) Observer 2 S. Hopkins (RR) Recorder S. Hopkins Pilot D. Scott (LF)

Aircraft Hughes 500D helicop Time: S 0615 F 1035 Speed 60 knots Altitude 200 ft. Weather: Current 0

Previous 24 Hours 7 Tidal State 2 Sea State 03

Ground Truth Survey Made yes 810620 S05-06 Zone Record on File yes

Zone Name or Number	Time Start End	Observer #1 Fresh Nest	Observer #1 Fresh False	Observer #1 Fresh Unk.	Observer #1 Old	Observer #1 Total	Observer #1 Species	Observer #2 Fresh Nest	Observer #2 Fresh False	Observer #2 Fresh Unk.	Observer #2 Old	Observer #2 Total	Observer #2 Species	Other Data (Stranding Boats, etc.
S01	0635-0642	0	6			0		0	0			0		
S02	0642-0647	0	0			0		0	0			0		
S03	0647-0659	0	0			0		0	0			0		
S04	0659-0710	1	1			2	Cc	1	1			2	Cc	
S05	0710-0720	9	6			15	Cc	5	7	1		13	Cc	
S06	0723-0730	5	17	3		25	Cc	6	18	2		26	Cc	12 boats
S07	0730-0736	4	4			8	Cc	2	6	1		9	Cc	2 dead turtles
S08	0738-0745	5	7			12	Cc	6	6			12	Cc	
etc.														

c. Date. Year, month, day. Example write 2 May 1981 as 810502.

d. Personnel. Give last names and all initials of all personnel and record seat each occupied (as right-front: RF).

e. Aircraft. Name and model.

f. Time. Use 24-hour clock (e.g., 2:00 p.m. = 1400) noting time of take off and landing.

g. Speed and Altitude. Give average for majority of flight.

h. Weather. Give weather description for both the time survey starts (over first zone) and for previous 24 hours, if known. If weather changes during the survey, note this at appropriate time(s) in the Other Data column. Use the following code:
0 = clear or few clouds
1 = partly cloudy or scattered clouds or variable sky
2 = cloudy (broken or overcast)
3 = fog, haze or smoke
4 = drizzle
5 = rain (widespread)
6 = rain with hail
7 = showers (scattered)
8 = thunderstorms (scattered)
9 = other, give details

i. Tidal Stage. Use following code:
0 = flood - exact stage unknown
1 = early flood
2 = maximum flood
3 = late flood
4 = slack before ebb
5 = early ebb
6 = maximum ebb
7 = late ebb
8 = slack before flood
9 = ebb - exact stage unknown

j. Sea State. Use the Beaufort Scale code numbers, as follows:

Wind Force (Beaufort)	Miles per Hour	Knots	Sea State (feet)	Description
00	0-1	0-1	0	Glassy
01	1-3	1-3	0-1	Rippled
02	4-7	4-6	1-2	Smooth
03	8-12	7-10	2-4	Slight seas
04	13-18	11-16	4-8	Moderate seas
05	19-24	17-21	8-13	Rough seas

Poor flight conditions higher than 05.

k. Ground Truth Survey Made. Check or write "yes." Give date of survey and zone number.

l. Zone Record on File. Check or write "yes" if a Zone Record Form has been prepared. If not, prepare one.

m. Zone Name or Number. Same information as on Zone Record Form.

n. Times. Use the 24-hour clock, to the nearest minute and identify local time to GMT. Record the time at the beginning of each zone surveyed in the appropriate column. If there is a specific reason to record several events within a zone, repeat the zone number.

o. Crawls. Fresh crawls are those made the night prior to the flight (except for the day-nesting Kemp's ridley). Old crawls are those made 24 hours or more prior to the flight. Depending on local conditions, crawls may remain visible from the air for only a few hours or for several months.

1. Fresh nest. Record the number of tracks having a definite body pit with signs of covering, for any tracks which occur in the intertidal zone. If tidal amplitude in some areas does not produce a wide intertidal zone, then local weather conditions may be used to delineate which tracks were made the previous night. Caution: lack of wind or deep, coarse sand may cause 1 or 2-day-old crawls to appear fresh from the air.

2. Fresh false. Record the number of tracks without a body pit or with a pseudo-body pit which does not exhibit any signs of covering for any tracks which occur in the intertidal zone. See above for cautions.

3. Fresh unknown. Sometimes it is difficult or impossible to categorize some tracks as nest or false. If the body pit is not visible or the field signs have been obliterated (this is a particular problem on beaches where nests are being moved to hatcheries), but the lower portion of the track is visible in the intertidal zone, record as fresh unknown. See above for cautions.

4. Old. On Form 2, record the number of old crawls as nest, false, or unknown (as above for fresh crawls). On Form 3, record only the total number of old crawls. In areas of high density nesting, trying to count all crawls, both fresh and old, may cause more inaccuracy in identifying the fresh tracks as nests or false. The researcher must decide which data points are more important and may choose to omit counting old crawls (Form 3), or to omit distinction of fresh from old crawls (Form 2, see below).

   Caution: rain and wind may cause fresh tracks to weather rapidly and appear old. Reliable ground truth is necessary to determine how well the aerial observers have determined the categories listed above.

5. Age uncertain. On Form 2, record the number of crawls as nest, false, or unknown (as above for fresh crawls).

6. Total. Enter the total number of crawls counted from the previous columns.

7. Species. Use the following code:

CC = *Caretta caretta*	loggerhead
CA = *Chelonia agassizi*	black turtle
CD = *Chelonia depressa*	flatback
CM = *Chelonia mydas*	green turtle
DC = *Dermochelys coriacea*	leatherback
EI = *Eretmochelys imbricata*	hawksbill
LK = *Lepidochelys kempi*	Kemp's ridley
LO = *Lepidochelys olivacea*	olive ridley
UK = Unknown species	

p. Other Data. Record any observed turtles and their behavior and any pertinent information such as turtle carcasses, nest predators, and fishing activity such as boats or nets.

As soon as possible after the survey flight, hold a debriefing session with all flight personnel and thoroughly check all record forms for accuracy, completeness and readability. Rewrite and make copies of forms as appropriate.

C.2.1.11 Shoreline Characteristics

These categories will be used in the initial aerial surveys for Zone Records (Form 1), and reconfirmed on subsequent flights, to record the nature of the shoreline. Determining which areas are most likely to be sea turtle nesting sites allows for more efficient planning for subsequent aerial surveys. More detailed study and recording of these features should be part of Ground Truth Beach Surveys (section C.2.2).

a. Sand Beach: General Comments. In addition to classifying sand beaches as high or low energy, they should be sub-classified as: sand only, sand and shell, sand and rocks, sand and vegetation, sand and driftwood. Beach color should also be recorded.

b. Sand Beach: High-Energy. Beach open to heavy surf with significant portion above high tide; profile is moderately steep. Dune height and condition.

c. Sand Beach: Low-Energy. Beach with gentle profile, breaking surf far from shore, often with several bars seaward of the beach. Dune height and condition.

d. Pocket Beach. Typically a small arcuate sand beach between cliff promontories.

e. Rocks. Rocks or reefs obstruct beach approach. Surf breaks on rocks.

f. Cliffs. Cliffs form shoreline. Surf breaks on cliffs.

g. Vegetation. Describe extent of vegetation above the high-tide line. Note types as: vines, grasses, mangrove, palms, or indeterminate.

h. Coastal Lagoons, Swamps or Marshes. Record: Narrow channels, wide lagoons, estuaries, mangrove swamps, marshes.

i. Human Development (on or near shore). Record: Houses, hotels, miscellaneous buildings, sea walls or shore protection construction, roads, paths, docks, anchorages, dredging, channels.

j. Human Use. Record: High, low, or no apparent human use; bathing, fishing, sand removal, beach cleaning, large/small vessels, fish traps.

k. Animal Use. Record: Cattle, pigs, goats, horses, wild animals, birds, crabs, iguanas, including tracks or signs of nest predation.

l. Nearshore. Record: Bare sediments, vegetated bottom, rocks, barrier reefs, patch reefs, gently sloping shelf or steep drop-off.

C.2.2 Ground Truth Survey for Aerial Beach Surveys

Ground truth surveys provide more precise and detailed accounts of the sea turtle activity, and in some instances of species identification, than can be observed from the air. Results from these surveys for a sample of beach area can aid in interpreting the results from aerial beach surveys over greater shorelines distances. They are essential for the third type of aerial beach survey (population estimate). The aerial survey is only as reliable as the ground survey determines. If the ground survey is not reliable, then the results of the flight cannot be adequately interpreted.

C.2.2.1 Location

Whenever possible, a ground truth beach survey should cover as many different types of beach as are covered by the aerial beach survey. The length of the ground survey will depend on the mode and ease of travel and density of tracks. If motorized vehicles are available and feasible, then each sample area can be enlarged. It should be no longer, however, than someone can travel on foot should the vehicle break down. On high density nesting beaches, a minimum number of tracks (perhaps 100) could be recorded rather than a linear distance. The zone or portion of a zone should be marked before the aircraft passes by so that the aerial observers can identify the ground truth section of beach separately on their record forms.

C.2.2.2 Time

Ideally, the ground truth survey should be made early in the morning on the same day as the aerial beach survey. This would not be possible where sea turtles (e.g., Kemp's ridley) nest during the day.

When ground surveyors are already making routine or special night time visits to a nesting beach to record and tag females, then they should make one last survey of the beach at dawn. Data on tracks recorded throughout the night may not be accurate by morning if tides have erased some crawls. Ground surveys, in order to be a useful comparison for aerial beach survey, must coincide with the timing of the flight as closely as possible.

C.2.2.3 Data Recording Forms for Ground Truth Beach Surveys

Form 4 is intended for use in conjunction with aerial beach surveys. However, it can also be used for daily records of false and nesting crawls when the same beach is being surveyed on days other than flight days. Form 4 is the very least that is needed for ground truth. It provides only the totals for each type of crawl appearing on the beach at the time of the fly-over. By comparing the data from Form 4 with those from Form 3, the following can be determined: a) aging bias, b) nest to false crawl bias, c) percent of unknowns and unknown bias, and d) if all crawls were seen by aerial surveyors. See Form 4A for a completed version.

Form 4. Explanation

a. Details on upper part of form are explained in C.2.1.10 (Data Recording Forms for Aerial Beach Surveys).

b. Species. Record the one or more identified or list as species unknown (UK).

c. Unknown. When there appears to have been a nest laid but eggs could not be located upon probing.

Form 5 provides a sequential, detailed picture and map of what appeared on the beach at the time of the flight. In order to record these data the beach must be divided into segments that are known to both the aerial and ground crew. Natural landmarks, conspicuous signs or posts or large numbers drawn in the sand will do. Should the aerial observers lose the correct sequence of the crawls, the sequence is reestablished at each landmark. One-half mile intervals are convenient for most aircraft speeds. The ground crew also describes the appearance of each crawl as well as its location. Ground truth from Form 5 would be compared to aerial data from Form 2 or from transcribed tape recordings where the landmarks and crawl descriptions were also made.

This type of survey allows a direct crawl by crawl comparison. In addition to determining the biases mentioned before, it will enable the researchers to determine the type of errors being made and the accuracy of the survey. See Form 5A for a completed version.

Form 5. Explanation

a. Same as above for upper part of form.

FORM 4.

Sea Turtle Aerial Beach Survey

Form 4: GROUND TRUTH BEACH SURVEY

Page____of_____

Aerial Survey Made_____

Zone Record Form on File_____

Country_____ Survey Leader_____

State_____ Zone: Name_____ No._____

Start Survey: Date_____ Time_____ Shore Length of Zone_____ KM

End Survey: Date_____ Time_____ Portion of Zone_____

Weather: Current_____ 24 hrs._____ Length of Portion_____ KM

Other signs of Sea Turtle Activity_____

Human Activity_____

Species	Fresh				Old				Gr. Total
	Nest	False	Unk.	Total	Nest	False	Unk.	Total	
TOTAL									

FORM 4 A

Sea Turtle Aerial Beach Survey

Form 4: GROUND TRUTH BEACH SURVEY

Aerial Survey Made yes 810620

Zone Record Form on File yes

Country USA Survey Leader J. Coker

State South Carolina Zone: Name Sand Island No. 506

Start Survey: Date 810620 Time 0723 Shore Length of Zone 4.0 KM

End Survey: Date 810620 Time 0930 Portion of Zone entire

Weather: Current 0 24 hrs. 7 Length of Portion 4.0 KM

Other signs of Sea Turtle Activity none

Human Activity footprints on south end of island

Species	Fresh				Old				Gr. Total
	Nest	False	Unk.	Total	Nest	False	Unk.	Total	
Cc	4	12	1	17	6	18	4	28	45
Dc	0	0	0	0	0	0	0	0	0
Cm	0	1	0	1	0	0	0	0	1
etc.									
TOTAL	4	13	1	18	6	18	4	28	46

FORM 5.

Sea Turtle Aerial Beach Survey

Form 5: GROUND TRUTH BEACH SURVEY

Page____ of____

Aerial Survey Made_____

Zone Record Form on File_____

Country_____ Survey Leader_____

State_____ Zone: Name_____ No._____

Start Survey: Date_____ Time_____ Shore Length of Zone_____ KM

End Survey: Date_____ Time_____ Portion of Zone_____

Weather: Current_____ 24 hrs._____ Length of Portion_____ KM

Other Signs of Sea Turtle Activity_____

Human Activity_____

Track #	Species	Track Location			Age	Track Description
		Nest	False	Unknown		

FORM 5 A

Sea Turtle Aerial Beach Survey

Form 5: GROUND TRUTH BEACH SURVEY

Aerial Survey Made yes 83 05 27

Zone Record Form on File yes

Country USA

Survey Leader T. Murphy

State Florida

Zone: Name Hobe NWR - Jupiter No. F26-27

Start Survey: Date 83 05 27 Time 0450

Shore Length of Zone 18.7 KM

End Survey: Date 83 05 27 Time 0910

Portion of Zone Refuge and N. end of Jupiter

Weather: Current 0 24 hrs. 0

Length of Portion 11 KM

Other Signs of Sea Turtle Activity none

Human Activity moderate to high beach use in daytime

Track #	Species	Track Location			Age	Track Description
		Nest	False	Unknown		
1	Cc	4.1			new	good nest + body pit
2	Cc	4.2			new	good nest + body pit, crossed over track
3	Cc		5.0		old	no body pit, hit rocks
4	Cc	5.3			new	unequal track length
5	Cc	5.6			old	long track, several turns
6	Cc		6.5		new	low on beach, typical
7	Cc	7.0			old	all of track above high water line
etc.						

b. Location. Beginning of ground truth survey area by landmarks. Numbers represent the location of each crawl within the surveyed segment. Distances between segments are estimated to the tenth of a segment. A small sketch is made of each crawl to aid in direct comparison with the description from aerial observers.

C.2.3 Survey Charts

A survey chart should be prepared to accompany the other data forms for a survey. This chart should show zone boundaries and names, flight path, any ground truth surveys made, numbers of crawls recorded, and any other observations of interest (such as sea turtles and marine mammals sighted in the water). A sample chart is shown.

C.2.4 Pelagic Aerial Surveys

These surveys are made over water, usually following a previously designed flight pattern. Their purpose is to count sea turtles on the sea's surface. In clear and/or shallow areas, sea turtles beneath the surface are also counted.

Some of these surveys have multiple purposes: locating and counting sea turtles, marine mammals, sea birds, fishes, and fishing vessels, as well as identifying other vessel activities.

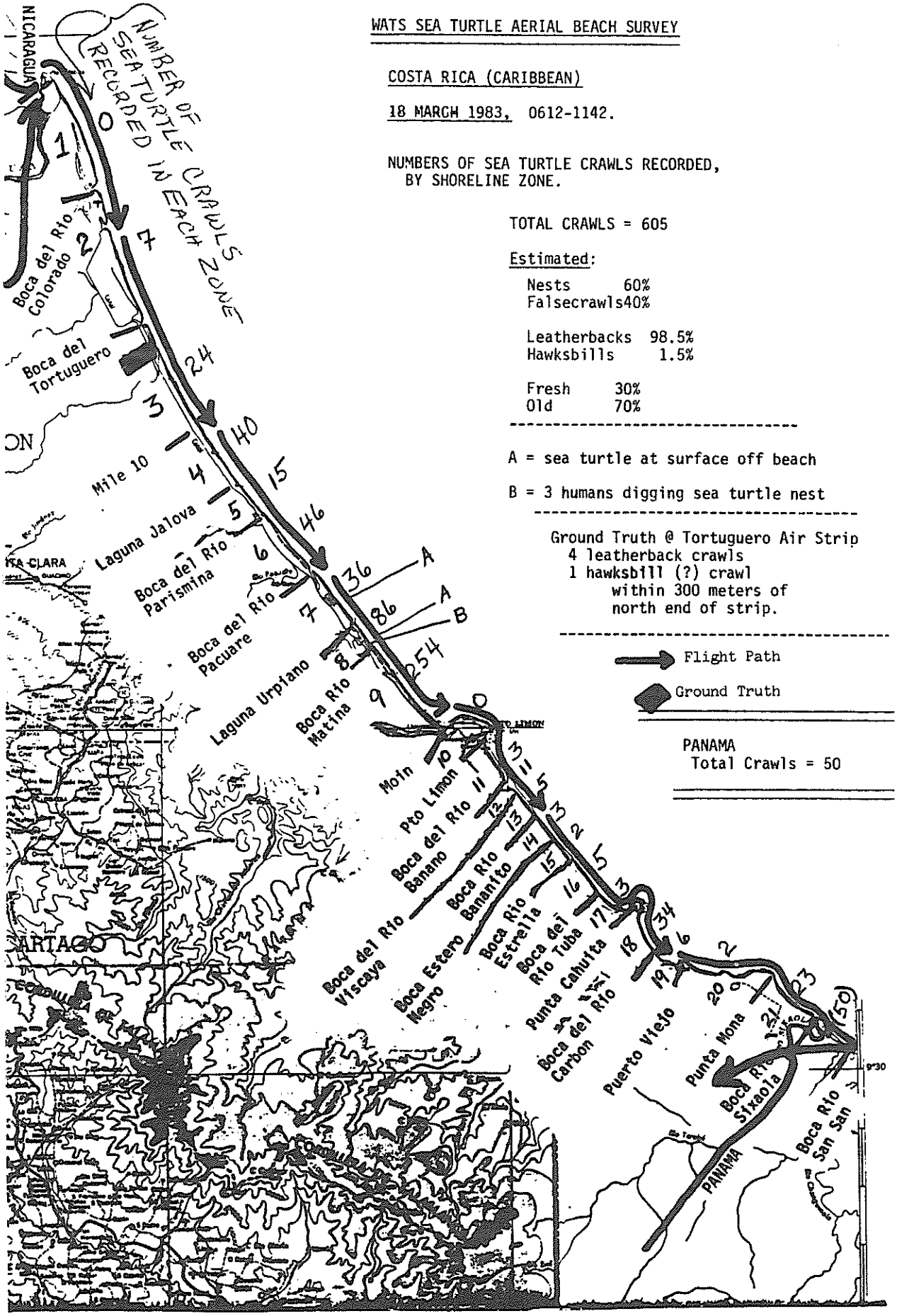
The following is a list of general aspects of pelagic aerial surveys and some suggested guidelines.

a. *Aircraft*. Most pilots and researchers experienced in offshore surveying recommend a two-engine aircraft. An aircraft with a nose observation station allowing the survey track to be seen is best. If such an aircraft is not available, a high-wing model is best because it offers optimum visibility. However, for relatively short over-water flights, or for survey patterns from one-half to two miles offshore, good results can be obtained with less costly single-engine, high-wing aircraft suggested for beach aerial surveys (C.2.1.1). All reasonable precautions are urged.

b. *Personnel*. A minimum of four is recommended with at least one observer seated on each side of the aircraft.

c. *Speed and Altitude*. With good visibility and calm seas speeds of 90 to 130 knots are satisfactory. About 110 knots is ideal. Elevation of 500 feet is probably best, with an acceptable range of 300 to 700 feet.

d. *Records*. A planned flight pattern usually consists of continuous offshore, along-shore, and inshore segments or legs. Record the starting and ending time and location of each segment and the times of sea turtle sightings and other related events along each segment. The relative positions of the events will be adjusted by time fractioning later. This is inefficient, however, so Loran C



WATS SEA TURTLE AERIAL BEACH SURVEY

COSTA RICA (CARIBBEAN)

18 MARCH 1983, 0612-1142.

NUMBERS OF SEA TURTLE CRAWLS RECORDED, BY SHORELINE ZONE.

TOTAL CRAWLS = 605

Estimated:

Nests	60%
Falsecrawls	40%
Leatherbacks	98.5%
Hawksbills	1.5%
Fresh	30%
Old	70%

A = sea turtle at surface off beach

B = 3 humans digging sea turtle nest

Ground Truth @ Tortuguero Air Strip
4 leatherback crawls
1 hawksbill (?) crawl
within 300 meters of
north end of strip.

Flight Path

Ground Truth

PANAMA
Total Crawls = 50

navigation should be used if possible for more precise offshore navigation and flight time. Sightability of turtles should be determined relative to distance from trackline, sea state, weather conditions, glare in viewing area, observer variability, etc. Utilize a statistically meaningful sampling design (e.g., line transect methodology) to interpret sightings.

e. *Data Forms*. Form 2 provided above for beach aerial surveys can be used also for pelagic aerial surveys. Code information for ease in handling, recording and processing data.

C.2.5 Other Aerial Observations

Sea turtle aerial surveys (Form 2) should also record information on the numbers, kinds and locations of vessels that may affect turtles. Such vessels include canoes and small power launches which systematically capture turtles for local consumption or commercial purposes and also larger fishing trawlers which may incidently capture turtles. Surveyors should be able to observe captured sea turtles, except very small ones, in open boats. Characteristic postures of turtle fishermen about to harpoon or jump on a turtle resting on the surface can soon be recognized.

It may be of interest to record all marine mammals sighted during sea turtle aerial surveys. Include species or genus identification (if known) or description, number, estimated size(s), and location. Concentrations of fishes or sea birds may also be recorded.

Photography can be useful to record dense crawls on a beach for later counting or for species identification. Recommended features are: shutter speed 1/1000 sec.; f-stop one setting higher (i.e., smaller aperture) than meter reading; color film 100-200 ASA; black and white film 32-64 ASA; expose perpendicular to the shoreline.

C.3 Vessel Surveys

Most sea turtle field research has been related to females and hatchlings on nesting beaches. Since relatively little is known about the rest of sea turtle life history, vessel surveys hold great promise for future research. Like aerial surveys and remote sensing techniques, however, vessel survey methods--what gear to use and how to capture and observe turtles--are still being developed.

Where sea turtles are relatively abundant, and where there are few bottom obstructions (as in Cape Canaveral Ship Channel on the east-central coast of Florida), trawling for 15 to 30 minutes with shrimp trawls or large-mesh trawls on the bottom is an effective method for live capture of sea turtles of both sexes and various sizes for tagging and other studies. Trawling is also useful for catching sea turtles on which to mount radio and sonic tracking transmitters for later monitoring.

The researchers can use three types of Vessel Surveys. In order of preference, they are:

a. Dedicated vessel. Preferred but most expensive method.
b. Dedicated observer aboard a cooperating commercial fishing vessel.
c. Ships of opportunity.

On a vessel dedicated either by contract or by outright ownership, the researcher can design a survey with minimal experimental bias.

This Manual does not attempt to instruct on proper statistical sampling design; however, the survey should strive for random spatial and temporal sampling, standarized sampling techniques (trawl size, down time, etc.), quantified catch per unit of effort (CPUE), and inclusion of all helpful data such as weather, sea state, glare, etc.

The sampling program of a dedicated observer aboard a commercial fishing vessel will obviously be limited by where and how the boat's captain chooses to fish. Hence spatial and temporal biases will almost certainly enter into the survey. Reduced program costs often outweigh these limitations, and most of the important data can still be acquired and the results can be statistically valid.

Ships of opportunity (vessels of any type without dedicated or trained observers aboard) can provide some useful data, but neither the level of effort nor much of the resulting data can be quantified. Although this type of survey can provide some insights into seasonal distribution, caution should be used in interpreting the data.

C.3.1 Data Recording Forms: VESSEL SURVEY RECORDS

The primary purpose of Form 6 is to record the number of turtles caught in a dedicated vessel survey; it can be adapted for use by observers on commercial fishing vessels.

Form 6 Explanation

a. *Vessel.* Enter name. Code numbers will be assigned later.

b. *Date.* Record date as per example: 2 May 1981.

c. *Cruise.* Since more than one survey cruise may be conducted aboard a particular vessel, it is best to number each survey separately. Enter 01 for the first cruise and continue consecutively.

d. *Station.* If particular stations are sampled, enter station number here.

e. *Latitude.* Enter latitude in degrees, minutes and tenths of minutes.

f. *Longitude.* Enter longitude in degrees, minutes and tenths of minutes.

Form 6. Sea Turtle Vessel Survey

Vessel_____ Date_____ Cruise_____ Station_____

Latitude_____ Longitude_____ Depth_____

Gear type_____ Door Size_____

Start set_____ Minutes fished_____ BTM Type_____

Air Temp._____ Surface Temp._____ BTM Temp._____ Barometer_____

Wind Dr._____ Wind speed_____ Tide_____ S.S.C._____ W.C._____

Turtle Sightings_____ Turtles Captured_____ Turtle Escapes_____

Total catch_____

TURTLE CAPTURE DATA

Spp.	Recap.	Tag Nos.	Carapace Length	Carapace Width	Sex	Cond.	Marks	Release Lat.	Release Long.

g. *Depth*. Enter depth of water. Indicate depth units used: fathoms, meters, or feet.

h. *Gear type*. Enter type of fishing gear (fish trawl, shrimp trawl, width of the mouth opening, etc.); numerical coding can be assigned later.

i. *Door size*. If trawl uses doors or otter boards, enter the size.

j. *Start set*. Enter time in hours and minutes when station is begun.

k. *Minutes fished*. Enter total elapsed minutes of fishing.

l. *Bottom type*. Enter type of bottom, i.e., muddy, sandy, etc.

m. *Air temperature*. Enter air temperature at time of survey.

n. *Surface temperature*. Enter surface water temperature.

o. *Bottom temperature*. If known, enter temperature of the water at depth.

p. *Barometer*. Record barometric pressure.

q. *Wind direction*. Enter wind direction.

r. *Wind speed*. Enter wind speed; specify units used.

s. *Tide*. Describe state of tide using this code: 1 = ebbing; 2 = flooding; 3 = high; 4 = low tide.

t. *Sea surface condition*. Enter sea surface condition, as described in Section C.2.1.12g under Flight Data Records.

u. *Weather condition*. Weather condition as in Section C.2.1.12f.

v. *Turtle sightings*. Enter number of turtles sighted at surface.

w. *Turtles captured*. Enter number of turtles caught in trawl.

x. *Turtle escapes*. Enter number of turtles that escaped while net was being brought aboard.

y. *Total catch*. Enter weight of total trawl catch, minus any turtles.

On the bottom of the form, record additional data on each turtle caught during the sampling. Include:

1. *Spp*. Species:

CC = *Caretta caretta*	loggerhead
CA = *Chelonia agassizi*	black turtle
CD = *Chelonia depressa*	flatback
CM = *Chelonia mydas*	green turtle

DC = *Dermochelys coriacea*	leatherback
EI = *Eretmochelys imbricata*	hawksbill
LK = *Lepidochelys kempi*	Kemp's ridley
LO = *Lepidochelys olivacea*	olive ridley
UK = Unknown species	

2. *Recap*. Was this turtle a recapture (already tagged)? *yes* or *no*.

3. *Tag numbers*. If the turtle was recaptured, record old tag number(s) and, if new or retagged, enter new tag number(s).

4. *Carapace measure*. Enter both carapace length and width. Specify units and method used.

5. *Sex*. Indicated as follows:
   M = Male
   F = Female
   U = Unknown

6. *Condition*. Code turtle condition as follows.
   1 = active, little or no growth on shell
   2 = active, heavy growth (barnacles, etc.) on shell.
   3 = inactive, sluggish
   4 = comatose or torpid
   5 = dead

7. *Marks*. Record any wounds, mutilations or distingushing characteristics.

8. *Release*. Enter the latitude and longitude of the release site, using format above (e and f).

C.4 Ground Surveys

C.4.1 Nesting Beach Surveys

One or more survey team members will patrol selected beaches, usually for two to eight hours after sunset, to record sea turtle activities and to measure and tag females when possible. Apparently, in many areas, particularly when low tide exposes rocks or flats, turtles come ashore on the rising tide as it approaches high tide, and return to the sea on the falling tide. However, patrols lasting the entire night are necessary to confirm this trend on a particular beach before briefer patrols can be designed to coincide with peak nesting hours.

Nesting beaches can be surveyed during the daytime; in Mexico, Kemp's ridleys invariably nest by day. Hawksbills in the Seychelles and flatback turtles in northern Australia also often nest during the day, as do olive ridleys during major *arribadas*. Daytime Ground Truth Surveys are also necessary to confirm aerial survey data. Sampling efforts and units should be clearly defined prior to and used consistently throughout a survey; this allows for comparison with other units

in the country or region and with published information. Generally, ground survey zones should correspond to aerial survey zones. However, if an aerial survey zone is relatively long (such as 32 km), the beach survey zone might be divided into smaller units (such as 10 sub-zones of 3.2 km each).

The following data should be recorded on beach surveys:

a. *Sampling Effort*. Dates and hours of patrol; length of beach covered (miles or kilometers).

b. *Weather Conditions*. Air and water temperatures; tide and moon phase.

c. *Turtle Activity*. Include:

1. Species identifications (from the turtle, its tracks and nest characteristics, or subsequent identification of hatchlings).

2. Number of turtles in each defined beach unit.

3. Number of nests. Include number of eggs laid in each nest only when this can be determined without handling the eggs excessively. It is wise to count only a small sample of nests.

4. Number of false crawls or false nesting attempts before successful laying, where this can be determined. For example, a single track may indicate several attempts to nest before nesting is successful; or an individual turtle may be seen on the beach and identified by her tag numbers for several successive nights before she finally nests successfully.

5. Turtle measurements (see Section C.4.2).

6. Presence of any prior tags (on flippers or shell) or evidence of the turtle having previously been tagged. Report serial number, kind, location, and return address of tags from other tagging projects. Do not remove old tags unless they are badly corroded or about to fall off (see Section C.4.3.7). If you remove an old tag, replace with a new tag. If only one tag is present, apply a second tag. Note any identifying characteristics (such as injuries).

7. Data on new tags placed on turtles during the survey, including serial number. Placement of tags and return address presumably will be same for all tags used, but should be stated (see Section C.4.3).

d. *Turtle Activity Records from Previous Nights*.

1. Number of old crawls, identified where possible as nesting crawls and false crawls.

2. Number of nests, identified when possible as: still incubating, hatched or disturbed.

3. Number of turtle carcasses. Record cause of death if it can be determined and other special markings or injuries.

4. Species identification.

e. *Hatching Success*. This should be based on either:

1. Subsequent observations (see Section C.4.5).

2. Egg removal to a hatchery, including description of transplant technique.

f. *Human Activity*. Examples include: egg harvesting, turtle capture, fishing, cattle herding, recreational activities, etc.

C.4.2. How to Measure Sea Turtles

Measuring turtles is often not important for basic conservation, but is of scientific interest. If time and manpower are limited, measuring turtles, particularly on nesting beaches, can be omitted. However, if protective legislation is to be based on turtle sizes, measurements can be of great value in determining the best size restrictions.

Procedures for measuring sea turtles are similar for all species, but measuring techniques may vary depending on the size of the turtle and availability of equipment. A variety of measurements have been taken in the past. This section recommends specific measurements, describes alternatives, and emphasizes that all measurements be precisely recorded.

C.4.2.1 Straight and Curved Measurements

A straight-line measure of carapace length and width is recommended (see Figure 12).

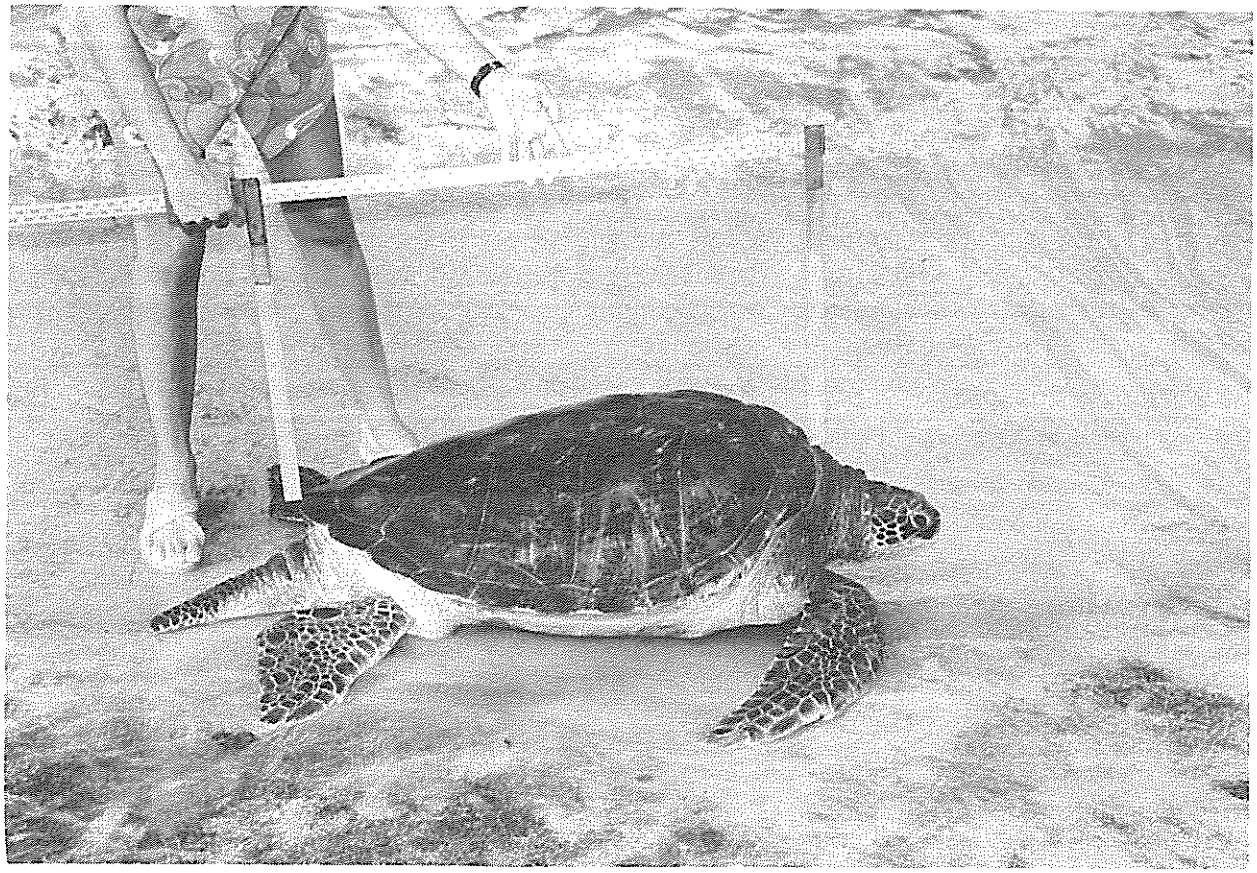


Figure 12. Measuring carapace length: straight-line method using calipers (recommended method). Photo by G. H. Balazs.

A sliding or hinged caliper (often available from forestry supply houses) is usually used, although a tape measure or ruler held parallel to and carefully aligned with the shell is an alternative. Another common but less preferable technique is a curved measurement in which a flexible metal or cloth tape is placed along the shell's contour (see Figure 13).

Recording both straight and curved lengths and widths gives a potential index to body thickness. All measurement records must specify which method was used. Both are described in more detail below.

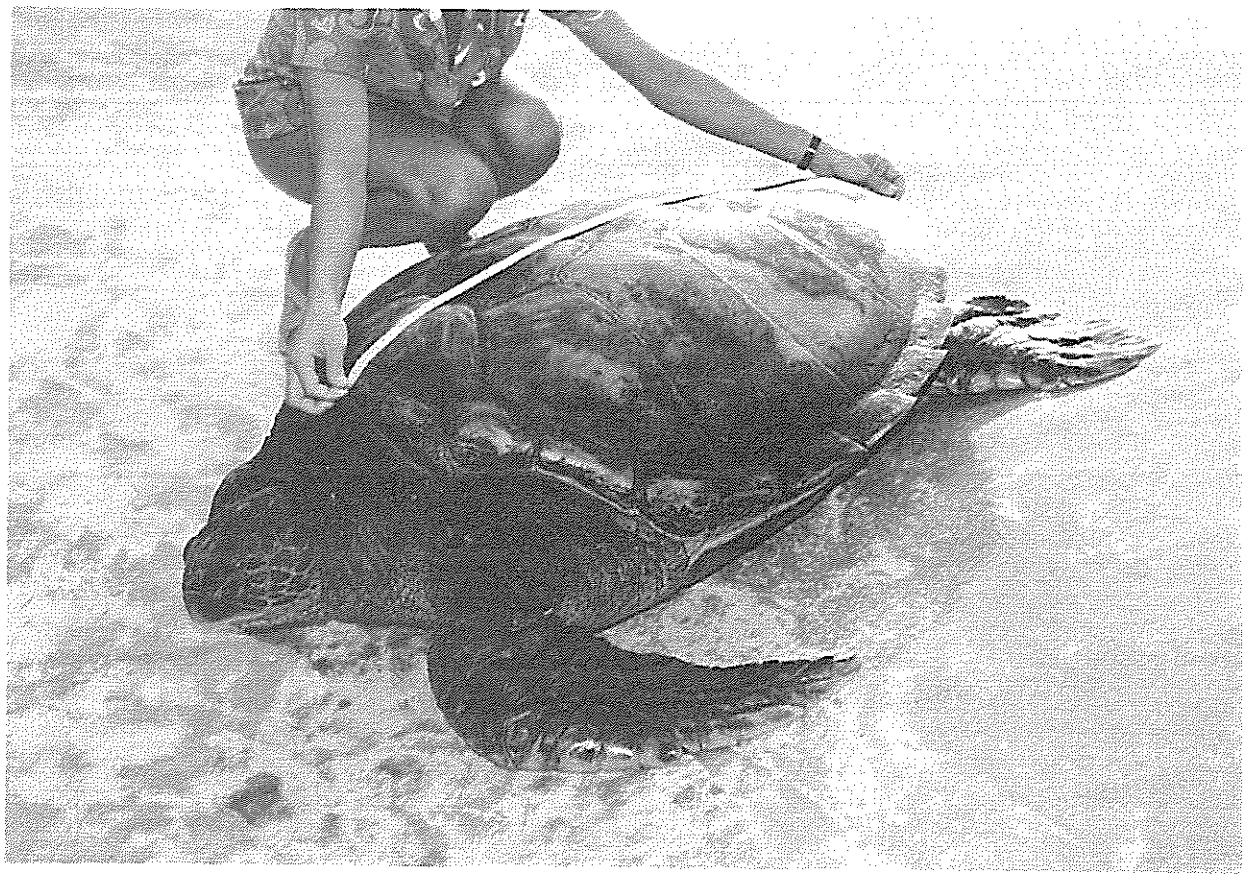


Figure 13. Measuring carapace length: curved-line method, using flexible tape. Photo by G. H. Balazs.

C.4.2.2 Standard Measurements

Four standard sea turtle measurements are defined in this Manual: a) carapace length; b) carapace width; c) tail measurements; d) weight.

Other measurements, such as head and plastron length and width, are not as important for applied research with which this Manual is concerned.

For nesting beach surveys in which only carapace length and width are being recorded in order to minimize disturbance, a female should not be turned on her back unless necessary.

C.4.2.3 Carapace Length

At least four different pairs of points have been used for measuring carapace length (Figure 14). Standard carapace length is recommended (see Figure 14, A). Any recorded measurements should specify which method was used.

Fig. 14, A. Standard carapace length (SCL) - precentral scute at carapace midline to posterior margin of postcentrals.

Fig. 14, B. Total carapace length (TCL) - anterior most edge of carapace to posterior margin of postcentrals.

Fig. 14, C. Notched carapace length (NCL) - anterior most edge of carapace to notch between postcentrals.

Fig. 14, D. Minimum carapace length (MCL) - precentral scute at carapace midline to notch between postcentrals.

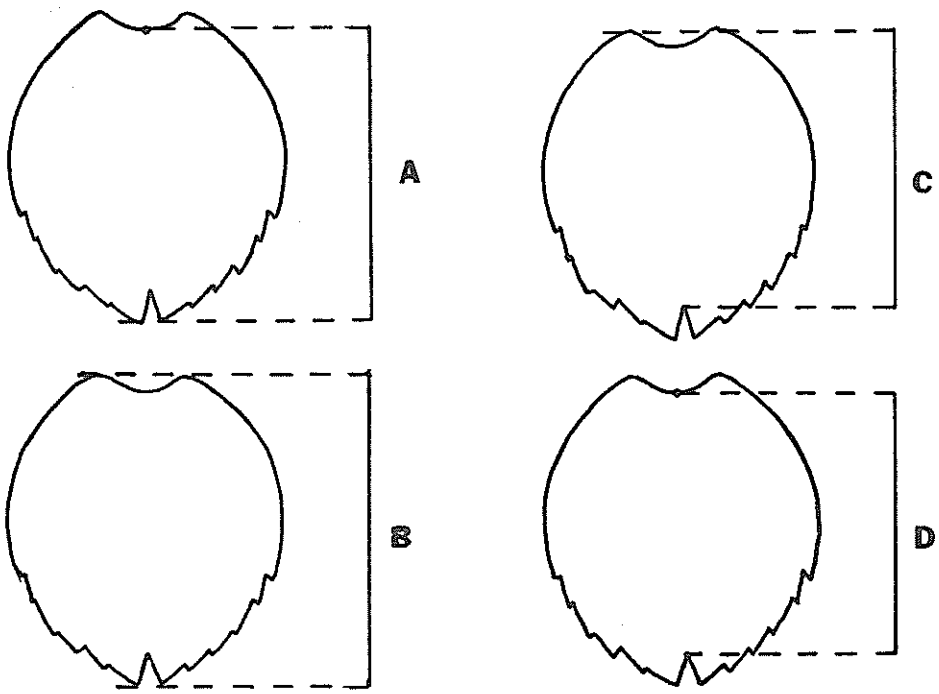


Figure 14. Four sets of anatomical points for measuring carapace length; A is preferred (see C.4.2.3).

The recommended method of measuring carapace length is straight-line standard carapace length (Figures 12 and 14,A). This measurement is more precisely defined as follows: the maximum straight-line distance along the midline from the anterior margin of the precentral scute to the posterior edge of the postcentral scute.

C.4.2.4 Carapace Width

Carapace width is the distance across the widest part of the shell, perpendicular to the longitudinal body axis. Straightline carapace width measurements are recommended (see Figure 15). If a curved measurement is obtained using a flexible tape, it should be clearly specified.

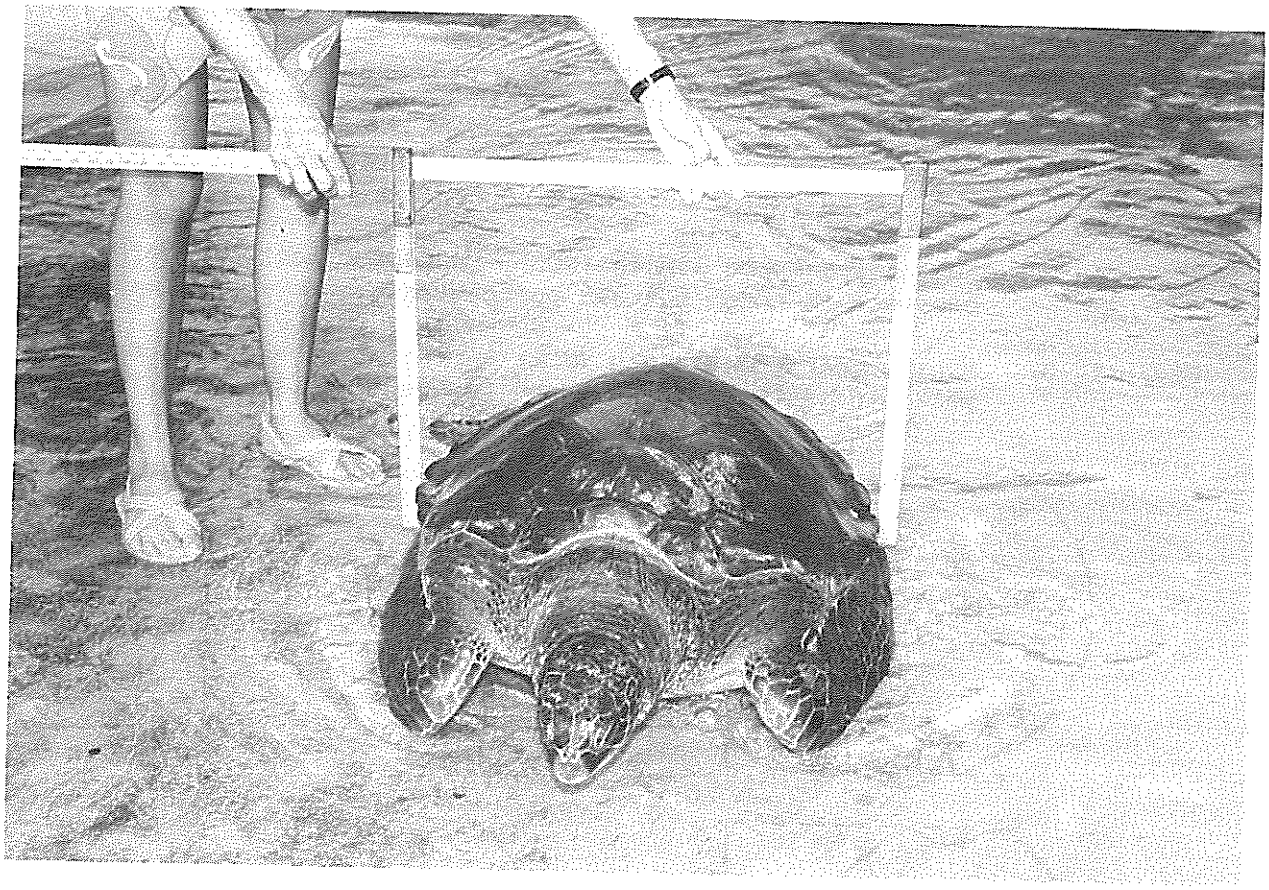
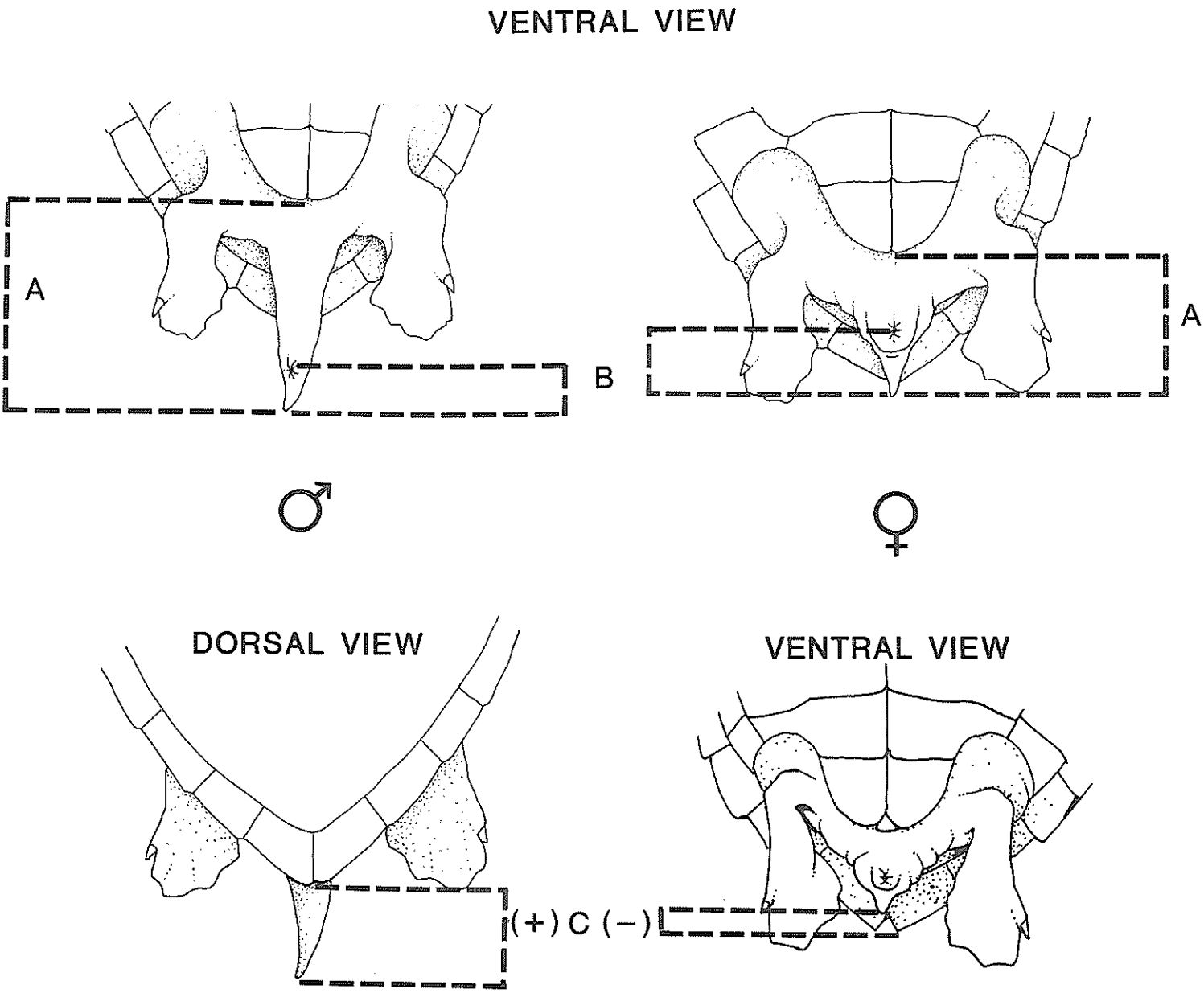


Figure 15. Measuring carapace width: straight-line method using calipers (recommended method). Photo by G. H. Balazs.

C.4.2.5 Tail Measurements

Tail length is the major secondary sex characteristic in mature sea turtles. Large sea turtles of all species with long tails that extend well past the posterior margin of the carapace are males (Figure 16, lower left). Similarly, large turtles having tails which do not extend or extend only slightly beyond the carapace are females (Figure 16, lower right). For subadult sea turtles, however, the relationship of tail length to sex is not known.

Along with carapace length and width, and weight (where possible) for size ranges of all species, tail measurements can help determine morphological and sex relationships. Tail measurements are only of value in non-nesting beach studies. Expending time and energy to measure the tails of nesting females would not be profitable in most cases. Three tail measurements are shown in Figure 16.



A. Posterior margin of plastron to tip of tail.
B. Mid-vent to tip of tail.
C. Posterior margin of carapace to tip of tail (with a plus sign prefix) or tip of tail to posterior margin of carapace (with a minus sign prefix).

Figure 16. Tail measurements (see C.4.2.4).

C.4.2.6 Weight

The weight range of the scale used should depend upon the weight of the turtle. Triple beam balances or spring scales can be used. A weighing device is available for shipboard use. Mount a large single beam balance (200 pounds, modified with supplemental weights for up to 500 pounds) to a block and tackle suspended from the ship's rigging. Place the turtle in a circular net (5-feet diameter) with a rope margin. Attach the rope to the beam's lower hook and hoist the turtle and net off the deck for weighing.

Nesting females can be weighed after nesting with a spring dial scale mounted to a horizontal pole. Tie or net the turtle to the scale and use the pole supported on the shoulders of two people to lift her off the beach for weighing.

Again, the weight data collected for nesting females may not be worth the effort expended, and the trauma to the turtles.

C.4.3 Tagging Sea Turtles

C.4.3.1 Preferred Tag Type

Turtles are usually tagged with Monel-alloy tags generally used for marking livestock. Several companies manufacture these tags; the authors will supply trade information upon request.

Tags come in sizes suitable for both adult and juvenile turtles. The largest are made from a metal strip 0.9 cm wide and about 8.5 cm long, which gives a folded length of 4.2 cm. The smallest tag shown in Figure 17 can be used on turtles about 2 kg in weight. Tag manufacturers supply special applicators; some resemble a simple pair of pliers with the working surfaces molded to fit and enclose a tag, while others have levers arranged to allow the tag to be clinched with less hand pressure. Figure 17 illustrates commonly used tags.

The code numbers (from National Band and Tag Company, Newport, Kentucky, USA) and base lengths for the three sizes of tags illustrated in Fig. 17 are: Small, No. 4, 2 cm; Medium, No. 681, 2.8 cm; Large, No. 49 or 19, 4.2 cm.

Tag manufacturers imprint, to the buyer's specifications, a serial number on one face, with or without one or more letter prefixes. Although not always done in the past, surveyors should co-ordinate with each other to avoid using the same numbers, since the different return address may not be noticed. The reverse side bears the tagger's or institution's name (usually abbreviated) and the permanent institutional address since tags may be returned many years after application. In some cases, the tag offers a reward to the finder of a tagged turtle.

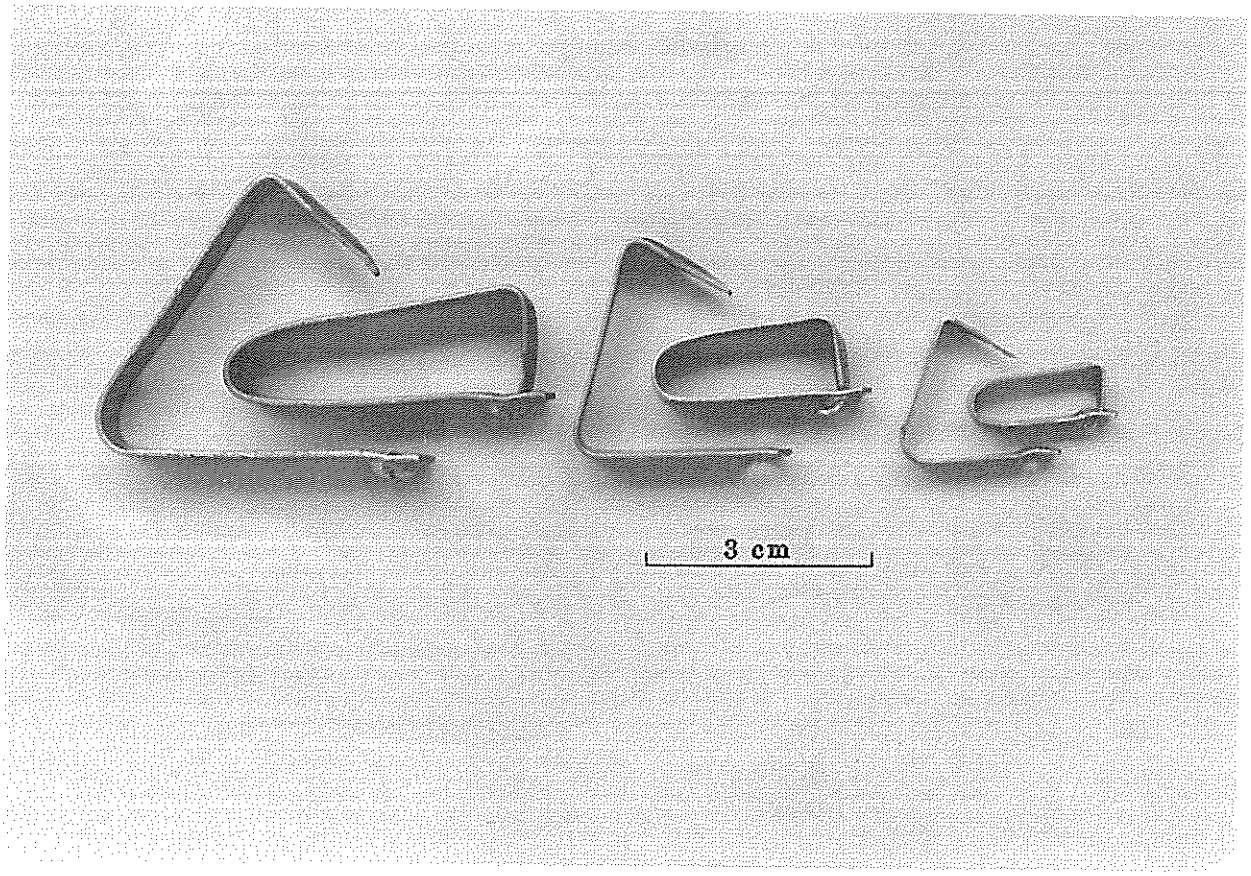


Figure 17. Commonly used flipper tags for sea turtles. Each of the three tags is shown in both the open and locked position. Photo by G. H. Balazs.

C.4.3.2 Where to Tag

Most workers tag turtles through the trailing edge of one fore-flipper, either proximal to, between or through the large scales edging the center part of the flipper (Figure 18). Some workers prefer to perforate the flipper with a pointed chisel before applying the tag. This can prevent the non-clinching that can occur when the turtle's tough skin deflects the tag tip.

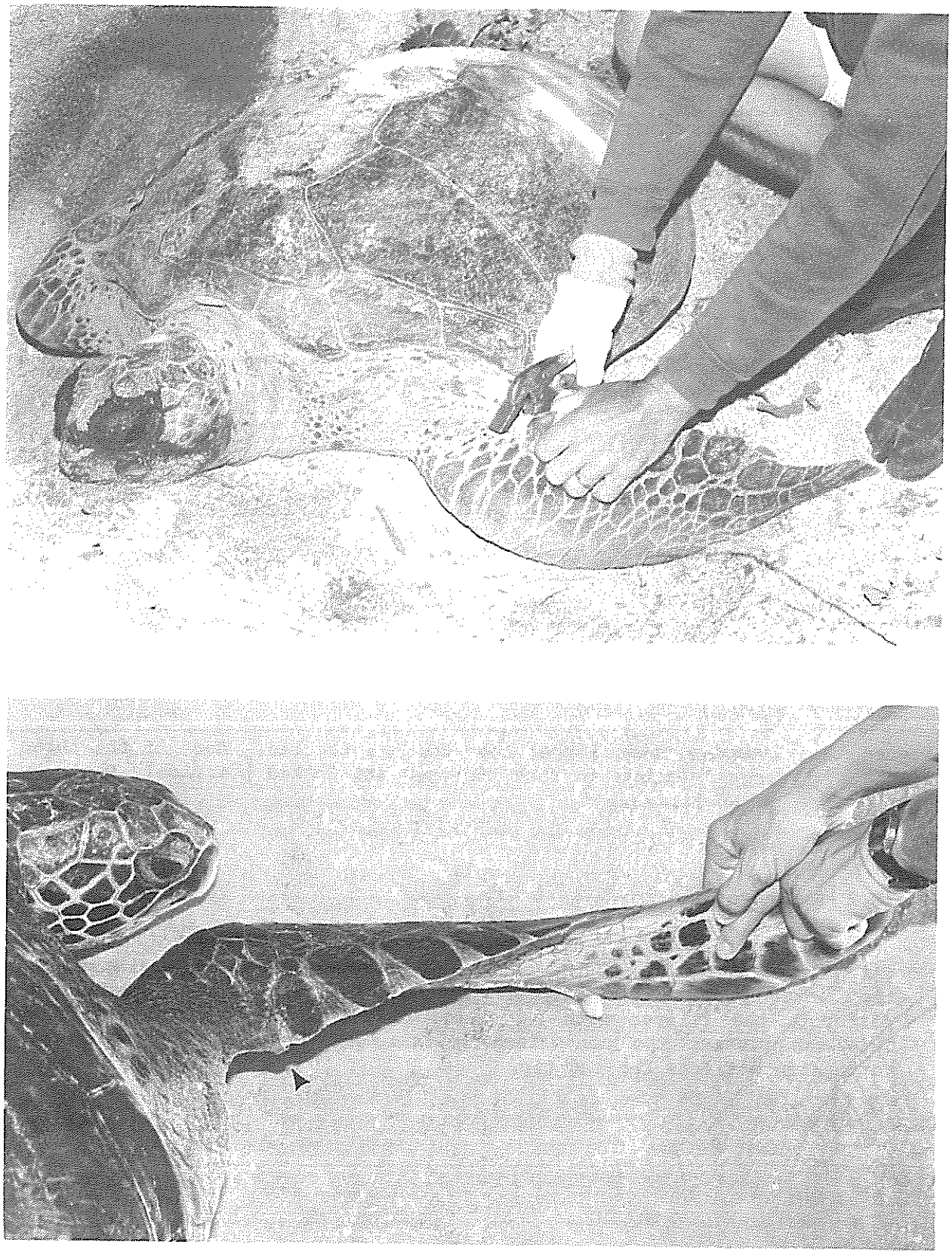


Figure 18. Method of tagging the trailing edge of foreflipper. Photo by G. H. Balazs

Double-tagging is recommended whenever possible. Separate (and usually consecutively numbered) tags are fixed to each front flipper. This procedure will partially offset the erratic loss of flipper tags.

C.4.3.3 When to Tag

Deciding when to tag a turtle depends on the conditions of each survey. If turtles are very numerous and if a large area must be patrolled or manpower is short, turtles may be tagged at any time. Ideally, however, the nesting females should be tagged only when the nesting process is completed, i.e., when the female has nested and started to return to the water. Some surveyors have tagged sea turtles successfully during oviposition, but others have found that some populations of sea turtles (especially green turtles), will stop laying eggs and start covering the nest if tagging is attempted. This Manual recommends that turtles be tagged as late as possible in the nesting process.

Some workers routinely turn turtles on their backs for tagging after nesting. This Manual, however, recommends tagging turtles while they are upright, if this is safe and convenient. The upright turtle should be restrained while one person holds the flipper and a second applies the tag.

C.4.3.4 Alternative Tagging Methods

Sometimes, a Monel-alloy tag applied as described stays on a turtle for more than a decade. However, a significant number a tags are lost quickly - often within a few weeks. Losses may occur when the tag tears through the flesh of the turtle's flipper, when the tag is clinched improperly, or when either the narrow bar that holds the tag tip corrodes or the entire tag corrodes.

Tags made with the more corrosion-resistant alloy, "Inconel 625," are better than Monel. Unfortunately, "Inconel" tags are not yet readily available, and the cost is relatively high. Titanium tags are now being used in Australia; evaluation is not yet available.

Some workers double-tag turtles and/or apply the tags closer to the tip of the foreflipper so that the clinched tag actually encloses the distal phalanges. This must be done carefully so that the tag does not wobble and interfere with the swimming stroke. If clinched firmly, the tags won't be torn out. Some turtle biologists report they can fix tags more firmly to leatherbacks' hindflippers than to their foreflippers.

The enterprising researcher may design and use tags completely different than those described. Early attempts at carapace tags (discs wired through the rear part of the carapace) were largely unsuccessful because the tags damaged the animal or were dislodged during copulation. A new type of carapace tag attached by a stainless steel bolt is being tested. Similarly, some researchers have had success with plastic tags; others have not. "Spaghetti tags" (long, thin, cylindrical pieces

of flexible plastic strung through a hole in the flipper and imprinted with a number and address) have been tried but do not appear to be satisfactory. Various other types of experimental tags have been described, and some have been tested.

C.4.3.5 Tagging Hatchlings

There is a pressing need for a method of marking hatchlings in a way that will remain distinctive when the turtle matures. The formidable obstacles to developing such a tag include the tremendous increase in biomass as the turtle grows from about 30 g to 100 kg or more, and the huge number of hatchlings that must be tagged to ensure reasonable odds of one or more surviving to maturity and being found. The methods proposed include grafting a piece of the light plastron onto the dark carapace and vice versa; inserting a magnet in the body cavity; causing the turtle to have a permanent immunological response to a certain antigen; excising particular marginal scutes, together with the underlying part of the bony shell, and for the leatherback turtles, clipping off the extreme posterior end of the carapace. A disadvantage of all these methods is that only someone familiar with the project and the tagging method could detect a tagged turtle. Also, the mutilation/excision marks may either heal completely and disappear or heal in a way that mimics a natural injury.

C.4.3.6 What to Record When Tagging

When a turtle is tagged, relevant biological data should be recorded. A tagging log should include the serial number of tag or tags, whether the turtle already had a tag, or a scar from a lost tag, the position of the tag, the date, time and location of tagging, whether or not the turtle nested, tidal and meteorological data, carapace length (ideally in a straight-line, but acceptable with a flexible tape if so stated), and possible other parameters (e.g., carapace width, weight). Tag data should be placed in a permanent depository, such as the files of a museum or government agency. No central turtle tag data clearing house now exists, though establishing one is under discussion.

Two Beach Survey data sheets presented in Section C.4.4 indicate the types of data that should be recorded. Data collection can be modified to suit the specific conditions of a given beach survey project.

C.4.3.7 What to Do When a Tag is Recovered

Many turtle tags are recovered by fishermen who have caught and killed the turtle. Tags are also recovered from turtles that were accidentally caught, and often killed, by shrimp trawlers and other trawlers. In these cases, the tag should be removed, opened up, flattened to fit into an envelope, and mailed to the address on the tag. An accompanying letter should give full details about the date, time, place and circumstances of the capture, the carapace length, weight, and the turtle species.

If a tagged turtle is observed nesting, or if a tagged turtle is caught alive and can be released alive, the tag should not be removed without good reasons. These reasons include: a) A tag that is badly corroded, about to drop off or is nearly illegible and has little further useful life. Sometimes the tag face is so damaged that the researcher should ensure that the number has been read correctly; b) Recapture of a turtle that the recoverer recognizes as an exceedingly unusual or noteworthy record; c) When the recoverer has tags and applicators on hand, an exceptionally old, worn tag or a poorly attached one can be replaced before the turtle is released.

C.4.3.8 Permits for Tagging Programs

Those interested in starting a sea turtle tagging project should consult with their own natural resources or wildlife agencies and obtain any required permits.

C.4.4 Data Form for Sea Turtle Beach Surveys

A standard data form for Sea Turtle Beach Surveys includes information on measuring, tagging, nesting and hatching. Form 7 is designed for use in a tagging program, but it may be used without tagging.

Form 7.. Sea Turtle Tagging and Nesting Data Form - Beach Survey.

SPECIES:_____NEST or FALSE CRAWL (circle which)

INVESTIGATOR: _____DATE_____TIME:_____

LOCATION: _____TIDE:_____

EVIDENCE OF PREVIOUS TAG (Circle) YES - NO

OLD TAG NUMBER 1: _____OLD TAG NUMBER 2: _____

NEW TAG NUMBER 1: _____NEW TAG NUMBER 2: _____

SURFWATER CONDITION (circle) CALM, MOD. (2-3 feet) ROUGH (3-6 feet) _____

CARAPACE LENGTH: _____cm inches (circle) WEIGHT: ____kg lb (circle which)
straight/curved (circle which)

COMMENTS: VEGETATION _____

STRUCTURES: _____

OTHER: _____

DISTANCE NEST CONSTRUCTED FROM MEAN HIGH WATER LINE: ___M FT (circle which)

TOTAL NUMBER OF EGGS: _____

FATE OF NEST: INCUBATION DAYS: _____NUMBER OF HATCHLINGS: _____

PERCENT HATCH:_____

COMMENTS: _____

TOTAL INVESTIGATING TIME: _____Hours/_____Minutes/

CRAWL DIAGRAM (Sketch here)

In a low density nesting situation, a separate page should be used for each turtle encountered. Sheets for multiple nesting by the same turtle should be collated. For *arribadas* or high-density nesting situations, fewer data may be recorded for each turtle, and data for several turtles may be included on one page of lined paper.

C.4.5 Determination of Hatching Success

Sea turtle population estimates depend, in part, on accurate assessment of number of eggs laid and number of healthy hatchlings that emerge.

The Sea Turtle Egg and Hatching Data Form (Form 8) defines the most important information needed for this assessment.

Form 8. Sea Turtle Egg and Hatchling Data Form.

Date Nest Laid _____ If Not Fresh, Estimate Age (Days) ___ Species _____

Date Nest Hatched _____ Days _____ Nest Excavated by _____

Location of Nest _____

Tag No. of Turtle (If Applies) _____ Incubation Method _____

Hatchling Data

Hatched eggs (H), from which hatchlings escaped from eggs _____

Hatchlings escaped from nest (HN) _____

Hatchlings dead in nest (DN) _____

Unhatched eggs (UH) _____

Turtles dead in pipped eggs (DPE) _____

Turtles alive in pipped eggs (LPE) _____

Infertile eggs with no obvious embryos (INF) _____

Unhatched eggs with discernible embryos (DE) _____

Deformed hatchlings alive in nest (DA) _____

Deformed hatchlings dead in nest (DD) _____

Survival Percentage of Hatchlings from Nest (SP) $= \frac{HN}{H + UH}$ _____

Comments: _____

_____

Weight of 20 Hatchlings Selected at Random from Nest (Living Turtles Only) (Grams).

1. _____	6. _____	11. _____	16. _____	Average Weight _____
2. _____	7. _____	12. _____	17. _____	
3. _____	8. _____	13. _____	18. _____	
4. _____	9. _____	14. _____	19. _____	
5. _____	10. _____	15. _____	20. _____	

Dispostion of Hatchlings (Released, Pen-reared, Other) _____

C.5 Market Surveys

Market Surveys can be used to assess the level and type of exploitation of sea turtles in an area.

C.5.1 Types of Data to Collect on Market Surveys

1. Name and location of market.

2. Date visited.

3. Number of vendors offering sea turtles or parts thereof.

4. Tabulation (in words) on numbers and species of live turtles each vendor offered.

5. Tabulation (in words) of turtle parts each vendor offered for sale. Products may include cut meat, tortoiseshell jewelry, souvenir shells, etc.

6. State whether market survey was complete (i.e., all vendors visited and their products examined) or was based on a sample. If a sample, estimate proportion of total market surveyed.

7. Prices asked for turtles and turtle products (state typical price and currency; highest and lowest prices; also state whether price is fixed or determined by barter).

8. Sources of turtles and season when available, according to vendors or other sources (interested or highly informed vendors should be asked the questions on the draft turtle survey questionnaire of Section C.6).

9. Measurements and weights of turtles or turtle shells seen:

   Species: Sex:

   Carapace length (straight): (curved):

   Carapace width (straight): (curved):

   Abnormalities and injuries:

   Notes on color and encrusting organisms:

   Weight:

   Date, location and method of capture:

C.6 Suggestions for Conducting Interviews

The following notes and draft questionnaire are suggested for use by scientists and fisheries officials when interviewing fishermen or residents of coastal districts.

Field procedures in sea turtle censuses and surveys should be a combination of direct observation and interviews. Repeated visits to one locale are difficult during most short-term surveys, but carefully planned interviews with knowledgeable local residents can yield data of great value. Interviews should be carried out systematically and with patience. The present outline aims to standardize interviews and ensure coverage of the key topics. The questioner ought to be prepared to conduct the interviews according to a mental checklist of the survey's objectives as originally conceived and as modified from time to time. The objectives are much the same in any interview, but the techniques will have to be flexible. Some informants may be willing and able to fill out a written questionnaire. Some may not. Asking a humbly educated informant to fill out a form can alienate him. He is likely to be even more offended when his answers are recorded verbatim. Taped interviews are useful, but some informants react negatively to requests to record the interviews, and even worse if recording is attempted secretly.

There are ways to surmount these problems. Keep in mind the procedural outline described below, and memorize the checklist. Write as little as possible during the interview but as soon as it is over, make notes and fill out the questionnaire in private. If there are gaps in the required information, and if the informant was good, return for additional questioning.

1. Data on the Informant

You should record the informant's name, address, approximate age and occupation. Try to judge his reliability; what opportunities he has had to get first-hand information; where he acquired his familiarity with turtles; and over what period of time. This assessment is one basis for grading each completed interview.

2. Species of Sea Turtles that Occur in the Area

Find out which species of turtles the informant believes are found in the area. Establish this by easy cross-questioning; <u>avoid prompting or leading him into more elaborate answers than his knowledge justifies</u>. Use the color plates of this Manual to aid in obtaining species identifications, but the informant should describe the species he is familiar with <u>before</u> being shown the illustrations.

After confirming the occurrence of a species, ask for all its local (vernacular) names (be they English, Spanish, Dutch, French, Miskito, Papiamento, Carib, or any other language or dialect in local use). When confident that the informant can distinguish one kind of sea turtle from another, record the names used and proceed with the interview.

3. Seasonality and Ecology of Foraging Adults

For each species, determine whether mature turtles occur in the region and how the informant knows they are mature. Ask if the turtles are present during the whole year or only during part of the year. Get information on both seasonal residents and seasonal migrants (see below). Be careful that the informant doesn't confuse the two; they are different. Try to determine the abundance of mature resident turtles of each species and in what habitats they live. Expect only a relative assessment, because there is no known way to count turtles in most foraging habitats. Nevertheless, for each species of resident adults, try to get a valid impression of population abundance and the extent of any local foraging habitat.

4. Developmental Colonies

Once the above data on resident adult turtles of each species are obtained, solicit the same information on the developmental stages, from yearling to submature sizes. Closely question anyone who seems to have a reliable understanding of the habitat distribution and seasonality of the various size classes.

5. Nesting

The most reliable quantitative population information that can be expected from this survey will come from nesting census data, especially in areas where tagging programs have been in progress. When asking questions about nesting, use charts and maps to identify likely sites of concentrated nesting. Also, get density-per-kilometer estimates for separate nestings by each species represented. Wherever warranted, supplement interviews with beach inspection and, in special cases, with aerial survey counts.

6. Changes in Population Levels

Another aim of the interviews is to determine if local opinion suggests whether the local population is stable or, if unstable, the way and degree that the population in changing. Although it is hard or impossible to determine the reliability of population stability estimates in most cases, estimates of fishing effort expended per turtle caught is one useful approach.

7. Migratory Routes

Migration, an important feature of sea turtle biology, has strong bearing on management. As suggested earlier, informants may not clearly distinguish migratory passage from the periodic occupation of developmental or foraging environments. During interviews, solicit local information about regular routes of migration. Ask the informant whether he has ever seen many turtles together at sea. If so, ask where, when, how many, what their average size was, etc. Ask what he believed the turtles were doing. Try to keep the idea of migratory movement separate from seasonal occurrence in a place or habitat.

8. Exploitation

In addition to gathering information on the kinds, abundance, seasonality, and habitat distribution of sea turtles, collect data on exploitation. Are turtles and turtle eggs used locally, exported, or both? What techniques do turtle fishermen use? During which seasons or months do they operate?

9. Turtle Laws and Regulations

To judge public awareness of restrictions and regulations, ask the informant what he can tell you about local turtle laws. Determine if he knows if it is legal to catch turtles; if there are closed seasons, quotas, or size limits; if it is legal to take eggs. This information will not only help to evaluate public awareness of, and attitudes toward, sea turtle regulation, but also will pave the way for the next line of inquiry.

10. Incidental Catch

Tag returns clearly show that, as shrimping fleets have grown, the frequency of turtles caught accidentally in trawls has risen strongly. Obtain estimates or records, if they exist, of numbers of turtles captured this way. Try to determine which species and size groups are caught, whether they are eaten by the boat crews and their families, are sold or are released, and whether there are regulations to control such incidental catches.

C.6.1 DRAFT QUESTIONNAIRE

1. Data on the Informant

Name: Sex: Age:

Address:

Occupation:

2. Species of Sea Turtles in the Area

a. How many kinds of sea turtles are known here? Describe them.

b. What local name is used for each of them?

CC = *Caretta caretta*	loggerhead
CA = *Chelonia agassizi*	black turtle
CD = *Chelonia depressa*	flatback
CM = *Chelonia mydas*	green turtle
DC = *Dermochelys coriacea*	leatherback
EI = *Eretmochelys imbricata*	hawksbill
LK = *Lepidochelys kempi*	Kemp's ridley
LO = *Lepidochelys olivacea*	olive ridley
UK = Unknown	

c. How do the various species rank in abundance?

d. Beside the turtles shown in Color Plates 1 - 40 (Annex I), do people ever speak of other kinds here? If so, what are their names, and what do they look like?

3. Seasonality and Ecological Distribution of Foraging Adults

a. Do fully grown turtles occur here? Which species?

b. Which species live in local waters year round?

c. During what seasons do other species occur?

CC = *Caretta caretta*	loggerhead
CA = *Chelonia agassizi*	black turtle
CD = *Chelonia depressa*	flatback

CM =	*Chelonia mydas*	green turtle
DC =	*Dermochelys coriacea*	leatherback
EI =	*Eretmochelys imbricata*	hawksbill
LK =	*Lepidochelys kempi*	Kemp's ridley
LO =	*Lepidochelys olivacea*	olive ridley
UK =	Unknown	

d. If turtles are seasonal here, do you have any idea where they come from?

e. How do you know this?

f. Do turtles arrive and depart on a predictable schedule, or a variable schedule?

g. In what kinds of habitats does each turtle species occur: channels, reefs, turtle grass beds, *Gorgonia* beds, mangrove creeks, others?

h. How many of each kind of turtle do you catch in a year?

i. On a good day, how many (total) do you catch: by netting, harpooning, diving, or by other methods?

j. How many days per month or per year do you fish for turtles?

k. Are there seagrass beds around here? Do you see adult turtles feeding on these grass beds?

l. Are there reefs around here? Are turtles common around these reefs?

m. Are there places where turtles are especially numerous?

n. Do you ever see turtles offshore? How far out? Which species? What size? Are they in groups? What did they seem to be doing? Are they associated with driftwood, seaweed, or just in the open sea?

o. Do you ever see any turtles mating?

4. Seasonality and Ecology of Developmental Stages

a. What sizes of each species do you find?

b. Which species of small turtles live here year round?

c. Do you find different types of small turtles in the same habitat? If not, what is the best type of place to find each kind?

d. Do the different sizes of the same species appear at different times of year?

5. Nesting

a. Do sea turtles nest locally? If so, which species? What seasons? Which beaches? How many in an average year?

CC = *Caretta caretta*	loggerhead
CA = *Chelonia agassizi*	black turtle
CD = *Chelonia depressa*	flatback
CM = *Chelonia mydas*	green turtle
DC = *Dermochelys coriacea*	leatherback
EI = *Eretmochelys imbricata*	hawksbill
LK = *Lepidochelys kempi*	Kemp's ridley
LO = *Lepidochelys olivacea*	olive ridley
UK = Unknown	

b. Are there any places where many turtles gather to nest together? If so, where? What species are involved? Does this happen occasionally or regularly? When?

6. Changes in Population Levels

a. Are sea turtles generally rarer, more numerous, or about the same today in comparison to years past?

b. How would you rate their abundance today as compared with 10 years ago, or 25 years ago?

c. To what do you attribute these changes? To annual catch? To changes in effort that has to be spent catching a turtle? To changes in nesting density on local beaches? To information you have seen in print? If so, where?

7. Migratory Routes

a. At certain times of the year, do you see turtles pass by that seem to be going to a particular locality?

b. If so, which species? What sizes? In groups, or singly? How big are the groups?

c. Describe the route they seem to be following.

d. Which way does the main current flow in this area? Does it affect the turtles' movements?

8. Exploitation

a. Is turtle meat sold locally? Is there demand for the meat throughout the country or only among the coastal inhabitants?

b. What is the current price of turtle meat per pound or per kilo?

c. Is meat exported to other countries? To which countries? Where is it processed?

d. How important is turtle meat in the diet of local people?

e. Which kinds of turtles other than green turtles are eaten, or sold for food?

f. Are turtle eggs sent to market? If so, what is the order of preference, if any, for eggs of the different species? Does the sale of eggs extend throughout the country or just along the coast?

g. Is there a market for turtle skins? What kinds of turtles are used? Who buys them? What prices are paid?

h. Is there a market for tortoiseshell? Is the market local or foreign? How much does the shell sell for (either by weight or per turtle)?

i. Are small turtles preserved or stuffed for sale to tourists and local residents? Which kinds? How much do they sell for?

j. Are turtles caught with spear guns, or by swimming, netting, or on the beach? By local people or by visitors?

k. How many people here hunt turtles for their main source of income? Are turtles captured by other fishermen as well?

l. How much subsistence capture is done by people who use their catch only themselves or among their family and friends?

m. Have the recent restrictions on international trade in sea turtle products had any effect on turtle hunting here?

n. If all export of turtle products were to stop, what would be the effects on local employment and local economies?

9. Turtle Laws, Poaching, and Smuggling

a. Do you consider the laws that prohibit or restrict taking and selling turtles fair or unfair?

b. Are the turtle laws generally respected, or do a lot of people poach?

c. Does the government make a strong effort to enforce turtle laws? How many officers does the government employ to enforce turtle laws locally?

d. Do the enforcement officers carry out their job, or are they half-hearted, or timid?

e. Have you ever heard of anyone getting caught for violating the turtle laws? Have you ever heard of any getting caught for violating the turtle laws? Have you ever heard of anyone being punished?

f. What kind of penalty usually is imposed?

g. How do poachers avoid the enforcement officers?

h. How many people would you say regularly take eggs or turtles illegally?

i. How important do you consider poaching's effect to be on the survival of local species?

10. Incidental Catch

a. Do trawlers work in local waters? Are they here all year or just in certain seasons?

b. Do trawlers or other fishing activities catch sea turtles? How do you know this?

c. Has this incidental catching of turtles increased lately?

d. Which kinds of turtles are taken, what sizes, and with what relative frequency?

e. Do the turtles usually drown in the net, or do most survive?

f. Are turtles caught by trawlers eaten, sold, or released?

D. Management and Conservation

The World Conference on Sea Turtle Conservation, held in Washington, D.C., USA, in November 1979, developed a "Sea Turtle Conservation Strategy" of world-wide scope which is published in Bjorndal (1982; see Reference section). This may be used as a reference document to establish priorities for national sea turtle conservation programs.

International cooperation, exchange of personnel, and consultation between turtle researchers and conservationists play an extremely important role in effective sea turtle conservation and management. For example, when many developing countries first established sea turtle programs, they arranged for national personnel to gain vital experience by participating in established turtle programs in other countries. Such exchange programs have many admirable results and invariably both veteran and novice researchers learn much that is new to them.

Recently, several national and international conferences on marine turtle biology and conservation have been held. Anyone comtemplating a major commitment of time and energy to sea turtle work should try to attend such meetings. Regional meetings such as those of IOCARIBE can be especially valuable. New information that is exchanged at such meetings may not actually be published for several years, if ever.

D.1 Beach and Nest Protection

The procedures recommended for nesting beach protection depend on the kind of predation and other conditions at any particular site. Most turtle conservationists agree that protecting nesting turtles is essential to maintain a viable population. Collection of eggs for human use must be carefully controlled, and in most cases, totally forbidden until turtle populations again reach acceptable levels.

Turtle eggs may be lost to:

a) Nest predation by man.

b) Nest predation by domestic animals.

c) Nest predation by wild or feral animals.

d) Erosion of the beach, flood tides, and other abiotic factors.

e) Nest destruction by later-arriving turtles digging up existing nests.

The investigator or turtle conservationist must monitor nesting and hatching to estimate the overall percentage of eggs that are lost for one or another of the above reasons. If losses are not great, manipulation or management of nests may not by necessary. If losses are great, protective measures should be instituted as soon as possible and continued as long as necessary.

D.1.1 Control of Predation by Man

The first conservation priority is to keep egg collectors and turtle poachers away, and to bring natural predators under control. Beach patrols are usually necessary for this. Several nations have found that a good course of action is to hire the most active poachers to work on these patrols, if it can be ensured that they will not draw

their pay while continuing to poach for profit. Such an approach curbs exploitation while drawing on the poachers' experience and expertise to benefit the turtles.

Effective patrols can be organized with assistance from military organizations, conservation officials and interested amateurs. Where sea turtles are under the auspices of fishery departments, local legislation might need amendment to enable enforcement officials and other wildlife specialists to assist in turtle patrols. If properly trained and organized, local amateur groups and naturalist societies greatly assist beach patrol and turtle protection efforts. Turtle hunters may be armed, and some turtle beaches can be dangerous. So care must be taken in recruiting amateur aides and they should carry some conspicuous form of identification.

D.1.2 Control of Domestic Predators

Domestic animals such as dogs and pigs destroy sea turtle nests and eggs on many beaches and must be controlled. When predator restraint or elimination is not possible, the nests should be moved to a suitable protected area.

D.1.3 Control of Wild Predators

Under normal circumstances, wild predators such as raccons and coyotes should not be exterminated. They should be controlled, however, when they are extremely populous and are destroying a large number of turtle nests, or where the turtle nesting population is already endangered. No entirely satisfactory control mechanism for such predation has been found. Experiments to reduce raccoon predation on loggerhead nests in the United States have had variable results. Experiments in which eggs are moved from the orginal nest to a facimile only a few yards away show some promise; both human and animal predators may be foiled by this strategy. But in some cases, a hatchery may be the only means of controlling predators.

D.1.4 Protection from Beach Erosion

Turtles may nest too close to the sea or in areas where high tides or storms are likely to erode the beach during incubation. The conservationist has several options discussed in Section D.1.6

D.1.5 Protection from Later Nesting Turtles

There are a few places in the world where turtles nest in such density that numerous nests are destroyed when other turtles subsequently arrive and dig in the same spot on the beach. Such nesting sites are unique natural laboratories for studies of what may be one of the few natural limits on turtle populations. But these beaches also provide an opportunity to enhance hatchling survival by moving some of the early-season nests to protected locations.

D.1.6 Egg Handling and Relocation

Sea turtle eggs should be allowed to incubate in their natural beach setting whenever they are likely to survive. Practical conservation management, however, sometimes requires that the nests be relocated. Consider moving the nests when one or more of the following situations occurs:

a) Heavy poaching has occurred in the nesting area during previous nesting seasons.

b) The nest is too close to the sea. For successful hatching, eggs should be laid well above the average high tide level.

c) The nest is close to artificial lighting.

d) Beach cleaning equipment is used near the nest.

e) Local populations of turtle egg predators such as crabs, pigs, lizards, etc., destroy a high percentage of nests.

f) Human use of the beach, including vehicle traffic, is intense.

g) Plant roots obstruct the upper part of the beach in a way that might block successful hatchling emergence.

Relocated eggs may have a lower than normal hatching success, but careful and rapid handling and transport of eggs reduce risks of relocation. Eggs can be removed during laying and before the turtle covers the nest. Taking care not to disturb the nesting turtle, deftly scoop the eggs out of the bottom of the hole or catch them gently in a plastic bag as they drop from the vent. Or, eggs may be excavated and retrieved from marked nests.

When excavating a turtle nest in which the egg pit was not precisely marked during laying, the following cautions are recommended:

a) Use extreme care in attempting to locate the eggs. To avoid punctures, only experienced personnel should use a probe to find eggs. Digging by hand is preferable. In many cases, the egg pit is on the seaward side of the nest, about 0.5 m deep. Leatherbacks and green turtles, however, bury their eggs deeper. Unless there is considerable time to dig by hand, probing may be necessary. The probe should be a wood or metal rod about 0.75 cm in diameter and 1 to 1.5 m in length. Whether probing or digging, be careful not to trample the nest area and compact the sand which will make locating the egg pit even harder. Once the probe starts "giving way" as it is pushed slowly through the sand, extract it immediately to avoid puncturing any eggs. If any eggs are punctured, remove them and all spilled egg contents to prevent the clutch from rotting.

b) Once the eggs are located, excavate them by hand. A shovel will break many eggs. Handle and transport eggs quickly, but with

utmost care. Place them on top of a thin layer of beach sand in a rigid container such as a styrofoam, wooden or cardboard box, or a strong basket. Shade eggs while excavating them on hot days. Hatchlings have a better chance to survive when eggs are removed and reburied within about six hours after laying.

If eggs are more than about six hours old, few will survive relocation unless they are kept with the upper surface or pole upright (i.e., without rotation). Maintain this orientation at all times when removing them from the nest, placing them in the container and transporting them. The top of eggs can be marked with a pencil. Put them in the new nest with the same axial orientation.

D.1.6.1 Beach Hatcheries

A beach hatchery should be located in a well-drained, unshaded level area that is free from vegetation. Although many designs for in-ground hatcheries have been used, the following design criteria are widely accepted (see also Figure 19).

a) The hatchery should be enclosed completely (sides and top) with aluminized or vinyl-covered wire mesh screen to keep out egg and hatchling predators.

b) The sides of the enclosure should be sufficiently strong to keep out mammalian predators such as raccoons and pigs. The sides should extend about 0.5 meter into the sand to keep out crabs and other burrowers.

c) Nests within the hatchery should be planted above the level of ground water, but not in completely dry sand as some moisture is essential for hatching. During very dry weather the nests might need to be moistened with a sprinkling can containing fresh water.

d) Wasted space should be avoided to reduce construction costs. However, when a hatchery is to be used throughout the nesting season, nest space should probably not be reused unless debris from earlier nests has been removed. The enclosure must be large enough to allow nests to be located about one meter apart to avoid trampling by personnel working the hatchery.

e) An artificial nest should resemble a natural nest in depth, diameter and shape. Each egg in the artificial nest should be in contact with other eggs. An enclosure of strong wire netting (having an approximate opening of 1 cm) should encircle each nest. The circle should be about 60 cm in diameter and 30 cm high, with the lower 5 to 10 cm buried in the sand. Emerging turtles will be trapped within the circle and should be counted before release. Most hatchlings emerge from the nest simultaneously, but stragglers may appear during the following few days. Always check all nests for any emerged hatchlings very early in the morning (no later than about 9 a.m.) and remove any

hatchlings promptly or the sun and hot sand will kill them. Five days after the initial emergence, excavate the nest and count any infertile eggs or dead embryos. Ghost crabs or other burrowing predators may have ruptured other eggs so the number of whole infertile eggs plus the number of hatchlings will not always equal the total number of eggs in the clutch.

Figure 19. Example of a protected beach hatchery. Photo by J. Fletemeyer.

Natural nests may be excavated in the same way after the young emerge, but exact calculation of the hatching success is seldom possible unless the eggs were counted as they were laid and the emerging hatchlings were also counted accurately.

To preserve a dead hatchling found in an excavated nest, inject 25 percent formalin into the body cavity through the soft umbilical area. If a hypodermic syringe is not available, the plastron can be cut open. Submerge it entirely in 10 percent formalin for storage. To retain it for taxonomic study or other purposes, transfer it to alcohol. Sometimes a very freshly preserved hatchling's sex may be determined by histological section, although few laboratories currently are equipped to do such studies.

D.1.6.2 Enclosed Hatchery Buildings

Although this Manual recommends incubating turtle eggs in a beach hatchery with artificial nests that closely simulate the natural nests as described above, sometimes such incubation techniques are impractical. When necessary, eggs can be incubated in containers in an enclosed building. Some researchers question this practice, however.

An enclosed hatchery must have good ventilation to maintain ambient temperatures that equal beach nest temperatures; research has shown that the temperature range affects the sex ratio of the hatchlings. Styrofoam "cool-boxes" offer incubating eggs fairly good protection from temperature fluctuations in an enclosed hatchery. The containers should be approximately 30 x 25 x 20 cm (internal dimensions). Adequate but possibly less desirable alternatives are small plastic garbage cans or plastic 20-liter (5 gallon) buckets.

When transferring a clutch of eggs to an incubation container, observe the following guidelines:

a) Drill or punch several small holes through the bottom of the container to facilitate drainage.
b) Line the bottom of the container with inorganic fine-mesh screen, such as nylon, to keep in the sand and to keep out ants.

c) Spread about 3 cm of beach sand on top of the mesh screen.

d) Place the eggs on top of the sand layer. Duplicating the position in which they were laid in the natural nest is crucial. Small nests may be incubated in individual containers, while larger nests (e.g., 150 eggs) should be equally divided into two containers.

e) Cover the top layer of eggs with fine-mesh screening (same as in b) to keep subsequent sand layer (see f) from settling between them.

f) Finally, carefully pour at least 3 cm of sand over the top mesh screen. Put on box cover. Have at least 5 cm air space between sand and cover. Check the sand's moisture content by pinching the surface of the sand with the thumb and forefinger. If a small peak of sand remains after the finger pressure is released, the moisture content is right. If the peak collapses, the sand is too dry, and sand that is too wet will not form a peak. Moisten the sand with a sprinkling can containing fresh water.

g) Store filled containers off the ground or floor, preferably on wooden racks or shelves. Do not stack containers on top of each other.

h) Two days before anticipated emergence, remove top mesh screen. Replace cover on box and leave in place until emerged hatchlings are to be released.

D.1.7 Release of Hatchlings

As hatching time approaches, monitor nests daily for emergences from both in-ground and indoor hatcheries. During cool, overcast or rainy weather, many hatchlings might emerge by day. As a rule, transport them immediately after emergence to a suitable site on the beach and release them. Keeping them too long retards their neonatal activity level; they will either fail to move when placed on the beach, or will be too sluggish to avoid predators. On beaches where hatchlings released during the day are subject to excessive predation (from birds, fish, etc.), many hatchery managers release them after sunset.

Released turtles may become disoriented, not only during their move to the water but also at sea. Carefully select a release site that is relatively free from natural predators. Do not release turtles near artificial lighting, piers, oil rigs or lighted offshore structures.

There is no consensus among turtle biologists on the best method for releasing hatchlings. Some maintain that natural conditions should be duplicated as closely as possible. They advocate liberating the newly hatched turtles high on the nesting beach so that if this phase plays a critical role in "imprinting," the turtle will return to the beach when it matures. Other researchers recommend taking the hatchlings by boat and releasing them beyond the surf line to avoid the high concentration of predators often found on the beach and in the surf. Both techniques should be used and in some cases combined; allow some turtles to run to the sea on their own, and release others beyond the surf line. If a large hatchery is being operated, do not release all hatchlings in the same place, but distribute them randomly at points well away from the hatchery area to avoid attracting predators.

D.2 Incidental Catch

D.2.1 Background

In some areas, incidental catch appears to be a major mortality factor for sea turtles. Turtles that become trapped in nets during shrimp trawling and fish seining may be injured or drowned. In addition to being an obvious problem for turtles, their incidental catch may interfere with commercial fishing operations and damage the gear.

D.2.2 Avoidance of Incidental Catch

This problem may be partly if not completely avoided and, consequently, the mortality reduced in three ways:

a) Areas frequented by large numbers of turtles can be identified and fishing activity in such areas restricted. Restrictions may be necessary only during certain seasons if the turtles concentrate for feeding or nesting only. Some shore-based fishermen who set nets near the beach leave their nets set during the

night to ease their work load. Turtles are often caught on their way in to the nesting beach. In Suriname, fishermen have cooperated willingly by raising their nets at night after the problem was explained to them.

b) Trawl nets and other fishing gear should be pulled up more frequently. A turtle rescued from a net in less than one hour of trawling normally has a good chance of survival.

c) Use of an excluder device on trawl nets reduces incidental catch significantly. The most effective device uses a trap door in the top of the trawl that opens to release large, heavy objects such as turtles and then closes again. Information on this can be obtained from the Southeast Fisheries Center, National Marine Fisheries Service, 75 Virginia Beach Drive, Miami, Florida 33149, U.S.A. Request NOAA Technical Memorandum NMFS, EFC-71 which contains detailed instructions on how to assemble, install and use an excluder device made from easily obtainable material.

D.2.3 Resuscitation of Apparently Drowned Sea Turtles

The time it takes to drown a turtle held under the surface by a trawl or other net is variable. The metabolism, and thus the oxygen demand, of a submerged turtle depends upon several factors, principally ambient temperature and activity level. Turtles caught in very cold waters, particularly dormant individuals dredged from winter hibernation sites, probably have a low oxygen demand and can survive for some time in a trawl. On the other hand, a turtle caught in a trawl in the tropics or in temperate zones during the summer has a high temperature, a higher metabolism and thus a shorter survival time in a trawl net. In addition, efforts to outswim an approaching net and struggles to free itself once trapped further increase its oxygen demand and dangerously shorten survival time.

Sea turtles caught in set nets or trawl nets may appear dead when brought to the surface or on the deck of a vessel. These animals do not move and their breathing and heartbeat cannot be observed without special instruments. Apparently lifeless turtles, however, may not actually be dead but may be moribund (approaching death). Field observations have demonstrated that many are only comatose and often may be revived.

To resuscitate an apparently comatose or drowned turtle, place it belly-down on the deck. Prop up the rear end so that the head is considerably lower than the tail. In this position, gravity can draw the water out of the turtle's lungs. Place the turtle in shade. An alternative resuscitation method is to place the turtle on its back and repeatedly push on the plastron with the foot to force the water from the lungs. However, some turtles, for reasons that are still poorly understood, die of anoxia without ever drawing water into the lungs while forcibly submerged. Comatose turtles will die if returned to the sea. Keep any apparently lifeless sea turtle out of the water for at least 24 hours and practice resuscitation, if possible, for 24 hours before presuming the turtle dead.

Sea turtles caught in nets and brought to the surface from very cold waters (less than 14°C) may have been hibernating in bottom mud. They may be dormant or comatose. If they are simply thrown back to the cold water, some or all of them might die from hypothermal stress. Until the physiology of this apparent hibernation is more thoroughly researched and understood, protect any sea turtles brought up from cold waters by temporarily storing them in warmer water before returning them to the sea.

D.3 Legislation and Enforcement

Successful sea turtle conservation depends on action at local, national and international levels. The primary goal is to give adequate protection to turtles at all life stages, and to ensure that growth, and especially reproduction and recruitment, occur with minimal interference. In addition, human use, exploitation and marketing of turtles and turtle products must be rigorously controlled until turtle populations increase and sustainable yields can be calculated and controlled. A few countries, such as Costa Rica and the United States, have completely prohibited capturing or molesting sea turtles, and have banned imports or exports of sea turtles and their products for commercial purposes.

D.3.1 National Conservation Legislation

Detailed suggestions for sea turtle conservation legislation to suit the conditions in all countries cannot be given here, but in general protective legislation should:

a) Protect sea turtle nesting, foraging and migration habitats.

b) Give nesting females maximum protection during the breeding season on beaches and in inshore waters.

c) Give maximum protection to nests.

d) Regulate capture at sea. Capture at sea often causes less damage to populations than captures on beaches or the taking of eggs, but it still poses a threat and should be regulated. Complete bans on capture may be necessary where turtles are considered endangered.

e) Regulate or prohibit all aspects of commercial marketing of turtles or their parts. Regulations should specifically forbid "holding," "offering for sale," or "causing to be offered for sale," any turtle or turtle product that is not legal.

f) Impose penalities for violating protective legislation that are sufficiently severe to prevent offenders from dismissing them as "the cost of doing business."

A nation or region starting a sea turtle conservation program should begin by reviewing all pertinent existing legislation. In the

archives of some countries are a tangle of old regulations--outdated, confused, generally unknown or ignored, but still technically in force. Such legislation may regulate fisheries, sale of foodstuffs, activities within coastal or marine areas and so on. If updated and rigorously enforced, these regulations may well give sea turtle populations their needed protection.

When some exploitation of turtles is inevitable, there is an honest difference of opinion regarding conservation priorities--whether it is better to allow some eggs to be harvested, to stress protection of small turtles (i.e., with a minimum legal size), or emphasize protecting larger breeding turtles (i.e., with a maximum legal size). The final decision will reflect cultural and biological considerations. Whatever extent and type of exploitation is permitted, however, must be linked to positive conservation action. For example, if controlled capture of turtles at sea during the non-breeding season is permitted, active protection--by nesting beach patrols and, if necessary, by hatcheries--during their breeding season is vital.

D.3.2 International Conservation Legislation

Existing international legislation can support national sea turtle conservation programs. Planners should familiarize themselves with various international conventions, and encourage their governments to ratify and enforce them. Because sea turtles migrate across national boundaries, international cooperation is essential.

Some of the existing relevant or potentially relevant conventions are:

a) **Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (1973)**

This Convention was designed to control international trade in endangered species, and their products and parts. Species threatened with extinction, listed in CITES Appendix I, are subject to strict trade regulation. All sea turtles are now included in this list. The last two sea turtle populations accorded this protective status were the Australian populations of *Chelonia mydas* and *Chelonia depressa* which were added to Appendix I at the CITES meeting in New Delhi in 1981.

As of December 1982, 77 nations have signed CITES, though a few have taken legal exception to the specific listings of several sea turtle species regarding trade regulation.

b) **Convention on the Conservation of Migratory Species of Wild Animals (1979)**

This Convention provides direction and guidelines for conservation of migratory animals, including sea turtles, and provides a mechanism through which nations can unilaterally act to conserve endangered migratory species. *Lepidochelys kempi* and *Dermochelys coriacea* are listed in Appendix I of the Convention as endangered species requiring immediate

protection, and all Cheloniidae and Dermochelidae are listed in Appendix II as species needing protection in certain areas.

c) **African Convention on the Conservation of Nature and Natural Resources (1968)**

This Convention theoretically offers a great deal of protection to sea turtles throughout the African continent; these species are listed as Class A (protected) species. In practice, several flaws exist: sea turtle eggs are excluded from coverage; nationals of Parties to the Convention are not covered when they operate outside their national territory; and the Convention's regional application does not cover all the sea turtle species involved. To date, 20 African nations have signed this Convention.

d) **Other International Conventions and Laws**

Several other conventions could be used to support national conservation efforts. Some have regional rather than global importance. One that has great potential application, but which, unfortunately, does not presently cover any sea turtle species is the Convention on the Conservation of Nature in the South Pacific.

In addition, Conventions and Treaties that ultimately may contribute to see turtle conservation, include:

i) The Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere

ii) The Convention on Wetlands of International Importance.

iii) The Convention Concerning the Preservation of the World Cultural and Natural Heritage.

iv) The Law of the Sea Treaty. Once it becomes international law, this treaty will affect Internal Waters, Territorial Seas, Exclusive Economic Zones, and the High Seas. Thus, it will embrace all sea turtle habitats except nesting beaches. Although not primarily a conservation treaty, it will help clarify and focus conservation responsibility for coastal resources such as sea turtles by allowing 200-mile exclusive economic zones for coastal nations.

D.3.3 Techniques for Setting Up Turtle Reserves

The legal procedures for establishing turtle reserves and refuges clearly differ from country to country. Several government programs proven effective in many countries are listed here; each nation can evaluate them in terms of its own local conditions. Laws or regulations protecting sea turtle habitats should be accompanied by legislation to protect the turtles themselves and their eggs. Enforcement patrols are necessary on intensively used nesting beaches. The patrols may be coordinated with biological research.

a) **National Parks.** These include designated areas where an ecosystem of national importance is maintained as undisturbed as possible. Both commercial and recreational exploitative activities are generally prohibited, though certain long-established activities in newly-designated park areas may be permitted for various reasons. Visitors to national parks are required to obey rules designed to protect the natural systems from damage. Many countries have established national parks which include and protect some of the world's most impressive landscapes and most important concentrations of wildlife.

Provincial and state governments may also establish parks and sanctuaries that can be as important and well-managed as national parks.

b) **Wildlife Refuges.** These areas may offer valuable protection for sea turtle breeding and nesting habitats. Recreational hunting and/or fishing is often permitted, but this does not interfere with turtle protection.

c) **Private Beach Ownership.** Private conservation initiatives offer a nesting beach good protection when one or more concerned landowners purchase property adjacent to the beach, and as far seaward as ownership laws allow. This is particularly effective when national parks have a seaward extension sufficient to protect turtles in adjacent waters as well as on land. If the foreshore is privately owned, preventing access to a beach from the sea is difficult; turtles may be poached either on the beach or just after they re-enter the sea. Private initiatives, however, only last as long as landowners cooperate; it is generally better to base protective measures in law. Private conservation efforts, nonetheless, sometimes have a greater permanency than government programs.

d) **Beach Construction Setback Lines.** Forbidding construction too close to the sea's edge not only avoids property destruction but also protects dunes and turtle nesting habitats.

e) **Other Measures.** In the United States, several additional programs protect marine habitats of turtles. For instanace, in an area designated as a Critical Habitat, federal activities or activities related to federal programs are barred if they are likely to jeopardize the continued existence of an endangered or threatened species. Two other useful federal programs are the Marine and Estuarine Sanctuaries. In a Marine Sanctuary, exploitation of marine species is prohibited (sometimes with certain exceptions). In an Estuarine Sanctuary, adjacent land is purchased and both terrestrial and marine habitats are protected. Where protected areas already exist that incude sea turtle nesting or foraging areas, conservation effort could be concentrated in these.

D.4 Care of Sea Turtles in Captivity

This section describes culture of captive sea turtles for research and conservation purposes. Commercial culture is outside the scope of this Manual.

D.4.1 Culture Techniques and Requirements

Hatchling sea turtles can be raised in captivity if water quality, temperature (minimum 20°C), sanitation, and diet are appropriately controlled. Experience has shown that some species are easier to raise than others: green turtles and loggerheads are probably the easiest, Kemp's ridleys are difficult, and leatherbacks are definitely the hardest to raise in captivity.

a) **Space.** Young sea turtles of some species are very aggressive in captivity. Kemp's ridleys in particular may violently and repeatedly bite each other if crowded. The resulting lesions may become infected and result in poor growth rates and an excessive number of deaths. Kemp's ridleys should be raised in individual containers. To diminish aggression to some degree in other species, use floating vegetation that allows turtles to hide from each other, and weight the food so that it sinks. Turtles bite each other mainly during the excitement of surface feeding. With hatchlings, the water must be shallow until they can dive to feed.

The space each turtle needs depends on the number of turtles kept together and other circumstances, so it is difficult to prescribe a fixed rule. A guideline is to provide a hatchling about one cubic foot (or 30 liters) of water and a subadult 18 cubic feet (or 2/3 cubic meter). Careful observation usually reveals whether turtles are crowded; if they are unable to swim freely or develop necrotic lesions on their necks and flippers, the density probably should be decreased.

When raising turtles in an outdoor tank, shade part of the tank from the sun unless the tank is very deep. If predators pose a risk, particularly to small turtles, cover the tank with netting. If possible, roof the tank completely.

Land areas are not desirable in tanks for rearing young turtles, because the turtles may crawl out on them and become dehydrated.

Leatherbacks do not adapt well to captivity; they swim into the walls of any enclosure and injure themselves severely. Attempts to rear them should not be made except under exceptional circumstances. Draping enclosure wells with a flexible material helps protect the turtles from injury. Sponge rubber "curtains" are not recommended because of their tendency to accumulate organic matter.

b) **Sanitation.** Hatchlings of all species are sensitive to water pollution and will suffer if pathogens reach high levels. Housing the turtles in "crawls" or other cages that are constantly flushed by sea water reduces pollution. Turtles, however, may escape during storm or other high tides while young turtles housed in tanks on land are more secure. If possible, install a system to supply clean sea water continuously. Flushing and completely refilling the tanks once or twice daily is an acceptable alternative. In inland installations where sea water must be conserved or other water used, a closed circulation system with adequate filtration and sterilization gives satisfactory results. Do not allow organic matter to accumulate in tanks. Pass-through systems should be drained and sterilized periodically, and tanks drained daily should be sterilized before refilling.

c) **Salinity.** Where estuarine water is used for captive rearing, the salinity should be monitored. Hatchlings are very sensitive to low levels of salinity; yearlings and older turtles are much more tolerant. Salinity of seawater is approximately 35 parts per thousand. Do not keep turtles in water with a salinity of less than 20 parts per thousand for any extended period.

d) **Health.** A detailed discussion of health care and disease control in captive turtles is beyond the scope of this Manual. In general, isolate sick animals and keep them in scrupulously clean sea water. External lesions will heal faster if painted with concentrated Gentian Violet or if the turtle is immersed in a solution of potassium permanganate (1 to 3 grams in 200 liters of sea water) until the lesions darken. Weekly, biweekly, or daily immersions in a potassium permanganate solution greatly prevents disease in captive turtles. A dilute silver nitrate solution can also be used, which also darkens the tissue.

e) **Feeding.** Post-hatchling turtles appear to be opportunistic feeders, and two species, green turtles and loggerheads, have been raised on diets of jellyfish. Most species in captivity can be fed proprietary food, pelleted food ("Trout Chow," etc.); filleted, skinned and boned non-oily fish, or the meat waste from crab or shrimp processing, Vegetable matter such as algae, lettuce, mangrove, *Sesuvium* leaves, seaweeds, and turtle grasses can supplement the diet of some species, particularly green turtles. Turtles raised on pelleted or artificial diets should be fed more natural food, if possible, for a few days or weeks before release.

Leatherbacks of all ages apparently require a highly specialized diet. As they are unable to digest fibrous food, they must be fed jellyfish or similar substances. Do not feed leatherbacks fish or plants, because they cannot digest such material.

It is emphasized that this section is not a complete or detailed Manual on rearing sea turtles in captivity. Anyone

contemplating a major turtle-rearing operation should visit facilities where turtles are being raised and consult in detail with their curatorial staffs.

D.4.2 Turtle Aquaculture for Conservation or Population Restoration Efforts

A topic much debated among turtle conservationists is the "head-start" procedure, whereby turtles are raised in captivity through the very vulnerable early months of life and then released.

By circumventing natural predators of young turtles, head-start programs may increase survival to maturity. However, this is still an unproven technique, because no clear-cut case has been reported of a head-started turtle reaching maturity and reproducing. Also, for head-starting to be proven to be a useful conservation tool, it must be shown that a greater percentage of hatchlings will reach maturity and reproduce successfully if they are head-started than if they develop naturally. Recent evidence suggests that green turtles and Kemp's ridleys released from a head-start program can function normally and integrate themselves into wild populations of sub-adults. Yet doubt remains as to whether turtles that spend the first months of their lives in captivity will have conditions of their natal beaches adequately imprinted in their adult behavior. The concern is that they might not migrate to appropriate locations nor come ashore to nest when mature, assuming that imprinting takes place.

This manual stresses that protection of natural populations and their habitats takes priority over head-start programs.

In deciding whether a given turtle population is suitable for head-start procedures, consider the following:

1) Head-start programs are expensive and demanding. The expense is justified only when the population is severely depleted and lacks protection from commercial exploitation.

2) It is suggested that no more than about 5 percent of the eggs laid should be head-started. The rest should be allowed to hatch and the young to reach the sea as naturally as possible.

3) All usual precautions must be taken to ensure maximum hatch of eggs (see section D.4.1 on hatchery techniques). After releasing the young, permit them to crawl down the beach from which the eggs came. Then gather them for release as they enter the sea. This may prove to be a meaningless excercise, but until researchers understand how turtles locate their nesting beaches, conservationists should mimic nature as closely as possible.

In addition to following the captive cultivation techniques recommended in section D.4.1, head-start programs should make an effort to prevent turtles from becoming too accustomed to one type of food. The curator also should prevent the turtles from associating him with feeding time, because this may later cause the turtles to form inappropriate responses to humans.

The duration of a head-start program depends in part on the facilities available. If a significant number of turtles are to be kept for more than a year, extremely spacious facilities and abundant regular food supplies are necessary. Most head-started turtles are released after six to fifteen months. Some programs keep them for from only a few days to two weeks, just enough time for them to absorb the yolk sac and acquire the ability to dive easily when threatened by birds. Such brief captivity, however, is not recommended because, while it may give the young turtle an advantage in avoiding predators, it presents the risk that the turtle will exhaust both its "infantile swimming frenzy" and its neonatal food reserves in captivity which it needs in order to reach its feeding habitat in good condition.

Before releasing head-started turtles, if they are large enough to carry a tag easily, tag them with the Monel flipper tags of appropriate size. Record each turtle's size and weight carefully so that later comparison can be made between captured head-started specimens and other turtles.

There are two philosophies regarding where to release head-started turtles. The first maintains that they should be placed in water where turtles in the same size-range naturally occur. The other advocates releasing turtles on their nesting beach at a time when hatchlings are emerging naturally. The latter treats the head-started turtles as if they were hatchlings, except that they are large enough to escape avian and certain marine predators. No decisive information is available on the relative merits of the two approaches. Therefore, the best strategy may be to divide the head-started turtles into two groups and apply the first method to one and the second method to the other.

E. Glossary of Terms

ABDOMINAL SCUTES - the third rearmost pair of plastral scutes; the largest of the scutes of the plastron.

ALVEOLAR - pertaining to the functional, or biting, part of the jaw.

ANAL SCUTES - the rearmost pair of plastral scutes.

AXILLARY NOTCH - the notch in the front part of the shell into which the front leg fits and from which it protrudes.

BEAK - the horny covering of the jaws, in turtles consisting of a single plate over each jaw surface. Also known as rhamphotheca or tomium.

BICUSPID - having two cusps.

BIFURCATE - having two branches.

BODY PIT - the depression dug by the female turtle during nesting. Body pits are characteristic of different species and range from shallow (ridleys) to rather deep (leatherbacks) and may persist for months under certain conditions. The center of the body pit does not indicate the position of the eggs.

BRIDGE - the part of the shell of a turtle that connects the carapace and the plastron.

CALLOSITY - a roughened area of skin, sometimes with superficial, sculptured bone exposed or just below the surface.

CARAPACE - the dorsal shell of a turtle.

CARUNCLE - the horny tubercle on the snout of a baby turtle used to cut through the eggshell.

CAUDAL - pertaining to the tail.

CENTRAL SCUTE - one of the large scutes extending down the mid-line of the carapace, also called vertebral scutes.

COSTAL SCUTE - any of the large plates that form the flanks of a turtle's dorsal shell, or carapace, located between the vertebral scutes and the marginal scutes. Also known as pleurals or laterals.

CRAWL - the tracks of the turtle on the beach. See false crawl.

CUSP - a sharp projection, typically from the edge of the jaw.

DEVELOPMENTAL HABITAT - the place where immature turtles feed and grow prior to reaching adult size. The developmental habitat of sea turtles may or may not correspond to the adult habitat and thus may require special conservation and management measures.

DISORIENTATION - the process of using incorrect cues for moving in a particular direction. For instance, hatchling sea turtles will move inland toward street lights instead of correctly toward the sea, and are thus said to de disoriented.

EMERGENCE - a. female. The term for the female turtle leaving the water and coming on land to nest.
b. hatchling. The hatchlings leaving the nest cavity on their way to the sea. This may not necessarily occur immediately after hatching.

ENDANGERED - any taxa likely to become extinct within the forseeable future if those factors responsible for its status continue operating.

FALSE CRAWL - the track left by a sea turtle that has ascended a beach but returned to the sea without laying eggs.

FARMING - the practice of culturing sea turtles in a closed-cycle system for commercial purposes. Farming does not rely on wild populations except initially, and later occasionally, to increase genetic diversity and avoid problems with inbreeding.

GROUND TRUTH - correlation between aerial surveys and beach surveys on a particular section of beach to obtain an estimate of the numbers of nests and false crawls. The number of nests and false crawls from

beach surveys (ground truth) is then compared with the numbers from aerial surveys to gain an index of the accuracy of aerial surveys on sections of beach where beach surveys are not possible or too time consuming.

GULAR SCUTE - the frontmost (paired, occasional single) scutes of the plastron, except in sea turtles where the paired gular scutes are separated by an intergular scute.

HALF-MOON - a semicircular or otherwise-shaped track made by a turtle that emerged from the sea but turned around and returned almost immediately.

HATCHERY - a manmade structure or enclosed area constructed for the incubation of eggs. Hatcheries may be relatively simple (i.e., a fence built around an area to which many nests have been moved) to complex (i.e., a building constructed to hold styrofoam boxes of incubating eggs adjacent to a nesting beach).

HEAD-STARTING - the experimental practice of raising hatchling turtles in captivity for the first months of life which may give them a better chance of survival when released.

IMBRICATE - overlapping, as the shingles of a roof or the scutes of the carapace of a hawksbill turtle.

IMPRINTING - the theoretical procedure by which a hatchling turtle receives a lifelong impression of its natal beach that enables it to recognize appropriate cues and relocate the beach when it matures.

INCIDENTAL CATCH - the capture of a species (such as a sea turtle) while fishing for another species (such as shrimp).

INFRAMARGINAL PORES - pores located near the rear of the inframarginal scutes. These pores are only found in the ridleys. The pores conduct secetory products to the surface, but the function of these products in unknown.

INFRAMARGINAL SCUTES - scutes situated between the marginals of the carapace and the pectoral, abdominal and femoral scutes of the plastron in certain turtles.

INGUINAL NOTCH - the notch behind the bridge and in front of the hind limb of a turtle.

INGUINAL SCUTES - scutes that form the anterior border of the inguinal notch.

INTERGULAR SCUTE - a small scute at the extreme front of the plastron of certain turtles, including sea turtles, that separates or partially separates the gular scutes.

LATERAL SCUTES - the large scutes running along each side of the carapace between the marginals and the centrals. Synonyms are costal scutes and pleurals.

"LOST YEAR" - the period of time between hatching and attainment of a carapace length of 20-30 cm during which sea turtles are rarely encountered. May not actually be a period of one year.

MARGINAL SCUTES - the small scutes around the edge of the carapace.

NECROSIS - rotting or death of tissues.

NEURAL BONES - the series of bones, eight or more in number, along the midline of the carapace. Anteriorly they contact the nuchal bone or proneural, and posteriorly they contact the suprapygal bone. In the series may be interrupted.

PECTORAL SCUTES - the pair of plastral scutes that cover the chest area--third pair from the front.

PERIPHERAL BONES - the bones around the edge of a turtle's carapace that lie beneath the marginal scutes.

PHALANGES - the elongate finger or toe bones in the flipper.

PLASTRON - the shell covering the underside of a turtle.

POSTCENTRAL SCUTES - posteriormost scutes on each side of the median line of the carapace, forming the posterior shell margin.

PRECENTRAL SCUTE - anteriormost and median scute on the carapace, included in the shell margin. Synonyms are cervical scute and nuchal.

PREFRONTAL - a bone in the turtle skull that extends from the nasal opening to the anterior part of the orbit; also a scale covering this area.

RANCHING - the process of raising sea turtles from eggs or hatchlings to some set market size for commerical purposes. This is not a closed-cycle system as it continuously relies on wild populations as a source for either eggs or hatchlings.

RARE - taxa with small world populations that, while neither endangered nor threatened, are at risk.

REMIGRATION - the return of adult turtles to a particular breeding area in succeeding years. Depending on the species involved, remigration usually occurs on a one (ridley), two, three, or four (most other species) year cycle. However, there are exceptions: Hawaiian male green turtles remigrate on a one year cycle.

SCUTES - the term for the horny scales covering the bony carapace and plastron, except in the leatherback. The shape of the scutes does not necessarily mirror the shape of the underlying bones, and scutes are named differently from the bones. Both scutes and bones are of taxonomic importance.

SERRATED - having a saw-toothed edge.

SWIMMING FRENZY - the heightened period of activity or rapid swimming of hatchlings out to sea following the emergence from the nest. The swimming frenzy lasts up to several days depending on species or population involved and may aid the hatchlings in clearing the surf and reaching developmental habitat.

SYMPATRIC - occupying the same geographic area.

T.E.D. - an acronym for Turtle Excluder Device. A structure fitted to a trawl specifically designed to reduce incidental catch, including sea turtles, and other non-target objects while maintaining normal levels of shrimp catch. The U.S. National Marine Fisheries Service has developed a T.E.D. that is effective in reducing mortality of turtles while maintaining or actually increasing the catch of shrimp.

TEMPORAL - the sides of the skull behind the eyes.

THREATENED - taxa likely to become endangered within the forseeable future. This is basically the same as the "vulnerable" category used by the International Union for the Conservation of Nature and Natural Resources.

TOMIUM - the biting surface of a turtle's jaws.

TORTOISESHELL - the scutes of the hawksbill turtle used in the manufacture of various items, particularly in jewelry. Green turtle scutes are sometimes also used but are harder to work, are thin and generally do not have the same beauty as genuine tortoiseshell.

TUBERCLE - a small lump or knotlike projection.

VERTEBRALS - the scutes of the carapace which overlie the backbone of the turtle except in the leatherback. May also be called central or neural scutes.

F. Sea Turtle References

The following annotated references are included because of the broad scope of contained information and general applicability to this Manual.

American Zoologist, Vol. 20, No. 3, 1980.

This symposium volume includes a series of valuable papers on many aspects of sea turtle biology; the conference that led to these papers was unlike most sea turtle conferences in that it concentrated on scientific rather than conservation aspects.

BJORNDAL, K. A. (editor), 1982. *Biology and Conservation of Sea Turtles*. Smithsonian Institution Press, Washington, D.C., 583 pp.

This volume is the most useful and detailed publication on sea turtles ever produced. Worldwide in scope, the included papers were presented in summary form at the World Conference on Sea Turtle Conservation, in November 1979, in Washington, D.C.

BONNET, B., (Updated) 1980. Introduction bibliographique a la physiologie de la tortue verte, *Chelonia mydas* (L.). *Collection Travaux et Documents*, No. 4 (UER Sciences), 31 pp., Centre Universitaire de la Reunion, Universite Francaise de l'Ocean Indien.

A valuable bibliography of the literature on the green turtle published between 1974-1979; includes papers on ecology, exploitation and protection, as well as physiology.

BUSTARD, H.R., 1972. *Australian Sea Turtles, Their Natural History and Conservation*. Collins, London, 220 pp.

A detailed discussion of Australia's abundant sea turtle fauna, of interest to readers worldwide.

CARR, A. F., 1952. *Handbook of Turtles*. Comstock Associates, Cornell University Press, Ithaca, 542 pp.

This has been for years the standard work on all turtles of the United States, including sea turtles.

CARR, A. F., 1956. *The Windward Road*. Alfred A. Knopf, New York. (Reprinted in 1979 by University of Florida Press; with new Preface and new photos, 258 pp).

CARR, A. F., 1967. *So Excellent a Fishe*. Natural History Press, New York, 248 pp.

This is a sequel to *The Windward Road*, giving the answers to some of the questions raised in the earlier book, and discussing progress made in answering others. (Reprinted in 1983 by Charles Scribner's Sons; with new Epilogue and new photos).

CARR, A. F., M. H. CARR, and A. B. MEYLAN, 1978. The ecology and migrations of sea turtles, 7. The West Caribbean green turtle colony. *Bulletin of the American Museum of Natural History*, Vol. 162, 46 pp.

GROOMBRIDGE, B., 1982. *The IUCN Amphibia-Reptilia Red Data Book. Part 1. Testudines, Crocodylia, Rhynchocephalia.* IUCN, Gland, Switzerland, 426 pp.

HIRTH, H. P., 1971. Synopsis of biological data on the green turtle, *Chelonia mydas* (Linnaeus) 1758. *FAO Fisheries Synopsis.* No. 85.

An in-depth summary of available information on the green turtle as of 1971.

HUGHES, G. R., 1974. The sea turtles of South-east Africa. Numbers 1 and 2. *Oceanographic Research Institute Investigational Report.* Volumes 35 and 36.

PRITCHARD, P. C. H., 1971. The leatherback or leathery turtle. *IUCN Monograph*, No. 1, 39 pp.

Although now outdated, this is a useful background document on available information on the leatherback turtle.

PRITCHARD, P. C. H., 1979. *Encyclopedia of Turtles.* T. F. H. Publications Inc., Neptune, New Jersey, 896 pp.

This is the current standard work on turtles of the world. It includes discussion of all species--land, fresh-water, and marine--but the sea turtle chapter is 76 pages long and includes color photos of all the species.

PRITCHARD, P. C. H. and R. MARQUEZ-M., 1974. Kemp's ridley turtle, or the Atlantic ridley, *Lepidochelys kempi. IUCN Monograph*, No. 2, 30 pp.

A useful summary of available information, as of 1974, on the most endangered species of sea turtle.

REBEL, T. P., 1974. *Sea Turtles.* University of Miami Press, Coral Gables, 250 pp.

This is a book-length updating of Ingle and Walton Smith, 1974: Sea turtles and the turtle industry of the West Indies, Florida, and the Gulf of Mexico. Particularly valuable for the detailed bibliography.

RUDLOE, J. J., 1979. *Time of the Turtle.* Alfred A. Knopf, New York, 267 pp. (Reprinted by Penguin Books, 1980).

A highly personal and engaging account of the author's experiences with sea turtles and insights into their mysteries.

SCHULZ, J. P., 1975. Sea turtle nesting in Suriname. *Stichtung Natuurbehoud Suriname*, Verh. No. 3., 143 pp.

Seriously interested sea turtle students may wish to read the *Marine Turtle Newsletter.* The current editor is: Dr. Nicholas Mrosovsky, Department of Zoology, University of Toronto, Toronto M5S 1A1, Canada.

PAGE INTENTIONALLY LEFT BLANK

MANUAL OF SEA TURTLE RESEARCH
AND CONSERVATION TECHNIQUES

ANNEX I

COLOR PLATES

NO. 1 - No. 40

PLATE 1. Adult male loggerhead. Note seconday male sex characteristics--tail extends well beyond a narrow, tapered carapace. Large head and reddish-brown carapace are characteristic of this species. (Photo, L. Ogren).

PLATE 2. Adult male loggerhead. Cloacal opening is located near tip of tail beyond posterior margin of carapace. Broad head is evident. Black sulfide-stained plastron is result of prolonged contact with silty bottom and is not typical of species. (Photo, L. Ogren).

PLATE 3. Sub-adult loggerhead. Two pairs of prefrontal scutes between eyes, five pairs of lateral scutes on carapace, and reddish-brown dorsal pigmentation are characteristics of this species. (Photo, L. Ogren).

PLATE 4. Sub-adult loggerhead. Three pairs of enlarged inframarginal scutes bridging the yellowish plastron are characteristic of this species. Marginate scutes of carapace are common in immature individuals. (Photo, L. Ogren).

PLATE 5. Juvenile loggerhead. Dorsal scutes have dark brown lines radiating from light centers. Each center is elevated and forms a sharp keel of spine characteristic of this age class. Photograph is of a 10-month-old individual raised in captivity. (Photo, Skidaway Institute of Oceanography).

PLATE 6. Hatchling loggerheads. Variation in intensity of pigmentation between siblings is evident. Species characteristics regarding scute and scale number and arrangement are similar to adults. (Photo, L. Ogren).

PLATE 7. Hatchling loggerhead. Specimen is typically colored, but has an extra pair of posterior lateral scutes and an extra pair of enlarged inframarginal scutes. Posterior pair of lateral scutes is asymmetrical. Umbilical scar is present. (Photo, L. Ogren).

PLATE 8. Juvenile Kemp's ridley and juvenile green turtle. The uniform black carapace is typical for Kemp's ridley up to about 28 cm carapace length (CL). The green turtle exhibits a pattern of broadly radiating streaks on each dorsal scute, which is typical of immature individuals. The head of the green turtle is proportionately smaller than heads of other species. The central keel of the carapace of immature Kemp's ridley is more pronounced than in adults. (Photo, L. Ogren).

1. Loggerhead

2. Loggerhead

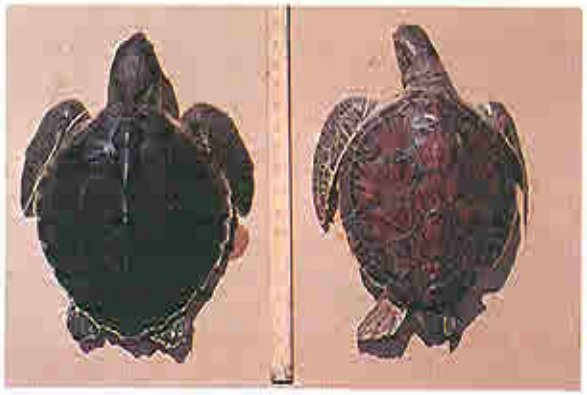
3. Loggerhead

4. Loggerhead

5. Loggerhead

6. Loggerhead

7. Loggerhead



8. Kemp's Ridley (L.), Green (R.)

PAGE INTENTIONALLY LEFT BLANK

PAGE INTENTIONALLY LEFT BLANK

PLATE 9. Juvenile Kemp's ridley and juvenile green turtle. Note keels on Kemp's ridley plastron and four pairs of enlarged inframarginal scutes, each with a pore centered on the posterior seam. The smooth, white plastron is typical of immature green turtles. (Photo, L. Ogren).

PLATE 10. Sub-adult Kemp's ridley. The olive-gray carapace of this older individual has replaced the black juvenile pattern except along the seams of the scutes. Distinct oval-shaped carapace, with five pairs of lateral scutes, and two pairs of prefrontal scutes are characteristic of this species. (Photo, L. Ogren).

PLATE 11. Sub-adult Kemp's ridley. The yellowish plastron is typical of older individuals. Four pairs of enlarged infragmarginal scutes bridging the plastron are present. The inframarginal pores are not clearly visible in this photograph. (Photo, L. Ogren).

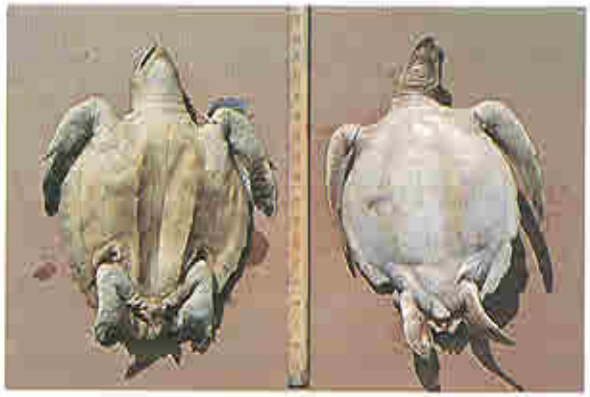
PLATE 12. Sub-adult Kemp's ridley. The small orbit located high on the skull above the deep upper jaw (supralabial scale) creates a parrot-like appearance--thus the Spanish vernacular name for this species, Tortuga Lora. The grey dorsal pigmentation of this immature individual is transitional between the black juvenile and light olive-green adult. (Photo, L. Ogren).

PLATE 13. Juvenile Kemp's ridley. The three elevated keels on the carapace, black dorsal pigmentation, and white plastron are typical of this age class. Photograph is of a nine-month-old individual (10 cm CL) raised in captivity. (Photo, L. Ogren).

PLATE 14. Hatchling Kemp's ridley. Kemp's and olive ridleys are the only species that have uniformly dark or black hatchlings. The five pairs of lateral scutes are typical for this species. Umbilical scar is present. (Photo, L. Ogren).

PLATE 15. Adult olive ridley. The dark olive carapace and the large and variable number (6-9) of lateral scutes are typical of this species. The oval-shaped carapace is characteristic of both ridley species. (Photo, P. Pritchard).

PLATE 16. Adult male hawksbill. Note the brightly patterned carapace with thick, overlapping scutes. Scutes in juveniles and older mature individuals are not overlapping. Hawklike narrow jaws and four pairs of lateral scutes are characteristic of this species. Elongate tail is exposed beyond posterior margin of carapace. (Photo, Miami Seaquarium).

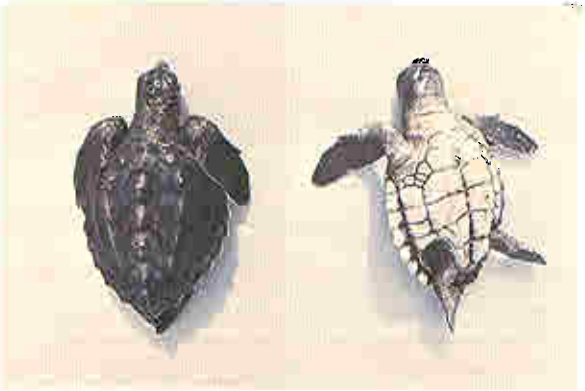


9. Kemp's Ridley (L.), Green (R.)

10. Kemp's Ridley

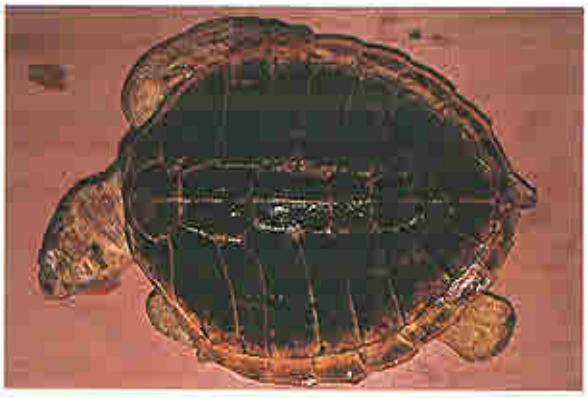
11. Kemp's Ridley

12. Kemp's Ridley



13. Kemp's Ridley

14. Kemp's Ridley



15. Olive Ridley

16. Hawksbill

PAGE INTENTIONALLY LEFT BLANK

PAGE INTENTIONALLY LEFT BLANK

PLATE 17. Adult male hawksbill. Note the elongated tail with the terminal cloacal opening (vent). The plastron and ventral area are yellow. The narrow jaws are characteristic of this species. (Photo, Miami Seaquarium).

PLATE 18. Adult hawksbills. Color variation between individuals is great. Two pairs of prefrontal scales between the eyes are present in all of these individuals and are characteristic of this species. (Photo, P. Pritchard).

PLATE 19. Adult female hawksbill. Bright or wet appearance of carapace temporarily lost while nesting. Note that the tail does not extend well beyond carapace. (Photo, L. Ogren).

PLATE 20. Hatchling hawksbills. Variation in coloration between individuals is evident. Superficially, these individuals resemble loggerhead hatchlings, but can be identified by their four, not five, pairs of lateral scutes. (Photo, L. Ogren).

PLATE 21. Hatchling hawksbill. Dorsal and ventral coloration and scute number and arrangement are typical. Note that the four pairs of lateral scutes on the carapace are all about equal in size. (Photo, L. Ogren).

PLATE 22. Adult female green turtle. Relatively small head and four pairs of lateral scutes on carapace are characteristic of this species. Color of carapace has changed from immature pattern (Plate 8) to an olive-brown with a scattering of dark spots. Carapace of this species varies from light brown to almost dark. (Photo, P. Pritchard).

PLATE 23. Adult female green turtle. Color and pattern temporarily obscured by drying of carapace while nesting. Small, rounded, and symmetrically shaped head is characteristic of this species. Female lacks the elongated tail. (Photo, L. Ogren).

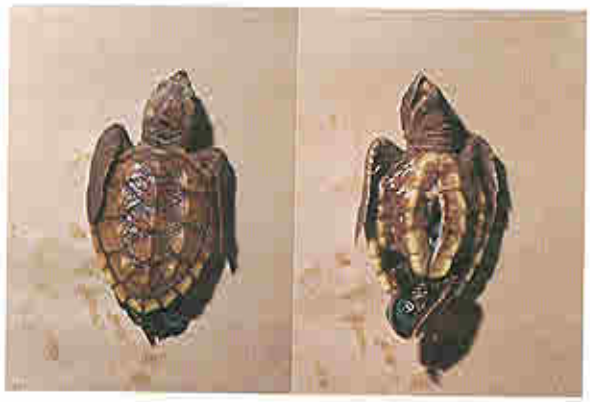
PLATE 24. Adult male green turtle. Light yellow ventral area is characteristic of the adults of this species. The sexually dimorphic and muscular tail of the male and distal position of cloacal opening are evident in photograph. (Photo, L. Ogren).

17. Hawksbill

18. Hawksbill

19. Hawksbill

20. Hawksbill



21. Hawksbill

22. Green

23. Green

24. Green

PAGE INTENTIONALLY LEFT BLANK

PAGE INTENTIONALLY LEFT BLANK

PLATE 25. Adult green turtle. Unique scale pattern of the head for this species is clearly depicted by the single pair of prefrontal scutes between the eyes. Biting edge of the lower jaw is serrated (not visible in photograph) and is unique to this species. (Photo, P. Pritchard).

PLATE 26. Juvenile green turtle. This individual falls within the size range of the age class commonly referred to as "yearling." This is about the smallest size that occurs in coastal waters other than hatchlings migrating away from their natal beach. (Photo, L. Ogren).

PLATE 27. Post-hatchling green turtle. The color and scute arrangement of this three-week old individual is typical of newly emerged hatchlings. Note the four pairs of lateral scutes and single pair of prefrontals, which are characteristic of this species. (Photo, L. Ogren).

PLATE 28. Adult female leatherback. Black dorsal area flecked with white spots and the absence of scutes are characteristic of this species. The seven dorsal longitudinal ridges run parallel to the body axis. (Photo, P. Pritchard).

PLATE 29. Adult female leatherback. Some individuals are distinctly darker dorsally than others, but the ventral region is predominantly lighter in color. Four of the longitudinal ridges can be seen on the right side of this individual. The front limbs are very long and the skin is rubbery to the touch. (Photo, L. Ogren).

PLATE 30. Adult female leatherback. The unusual tooth-like cusps on the upper jaw are visible in this photograph. The pinkish cast to the central area is most conspicuous where the dark pigment is absent. (Photo, P. Pritchard).

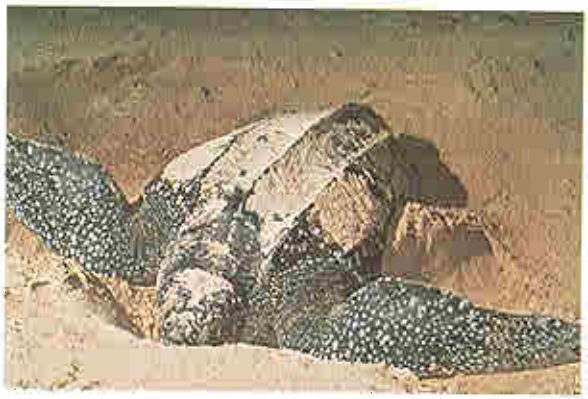
PLATE 31. Juvenile leatherback. Photograph is of a several-month-old individual raised in captivity. A mosaic of small scutes is present in hatchlings, but is shed after one or two months. (Photo, P. Pritchard).

PLATE 32. Hatchling leatherbacks. This typical color pattern for hatchlings remains almost unchanged in the adult, except that the light markings on the dorsal ridges and flippers become obscure or disappear. The hatchlings are densely covered with a mosaic of small deciduous scales. (Photo, L. Ogren).

25. Green

26. Green

27. Green



28. Leatherback

29. Leatherback

30. Leatherback

31. Leatherback

32. Leatherback

PAGE INTENTIONALLY LEFT BLANK

PAGE INTENTIONALLY LEFT BLANK

PLATE 33. Adult flatback. The characteristic three postocular scales are evident in this individual. The green turtle usually has four. (Photo, C. Limpus).

PLATE 34. Subadult flatback. The juvenile pattern has changed to a uniform olive-bluff carapace without markings. The borders between the carapace scutes are indistinct. (Photo, P. Pritchard).

PLATE 35. Juvenile flatback. This species is larger at hatching than the green turtle and soon loses the unique dorsal markings and coloration. (Photo, P. Pritchard).

PLATE 36. Adult male black turtle. The intensity of black pigment is characteristic of this species. The flipper injuries were caused by bites of other males competing for access to the female mounted by this individual. (Photo, P. Pritchard).

PLATE 37. Adult male and female black turtle. Note the heavily pigmented carapace and dorsum of both individuals. The male's tail is much longer than the female's. (Photo, P. Pritchard).

PLATE 38. Adult female black turtle. The heavy set of barnacles is unusual in the green turtle. The deep "mating scar" in the shoulder region is from the nail on the male's foreflipper used in grappling the female. (Photo, P. Pritchard).

PLATE 39. Hatchling black turtle. Coloration is similar to the green turtle, but the plastron soon darkens with age. (Photo, P. Pritchard).

PLATE 40. Adult hawksbill. The narrow jaws are characteristic of this species--an adaptation for feeding on reef prey such as sponges. (Photo, P. Pritchard).

33. Flatback

34. Flatback

35. Flatback

36. Black Turtle

37. Black Turtle

38. Black Turtle

39. Black Turtle

40. Hawksbill

W. A. T. S.