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 IOCARIBE

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

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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).

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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.

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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

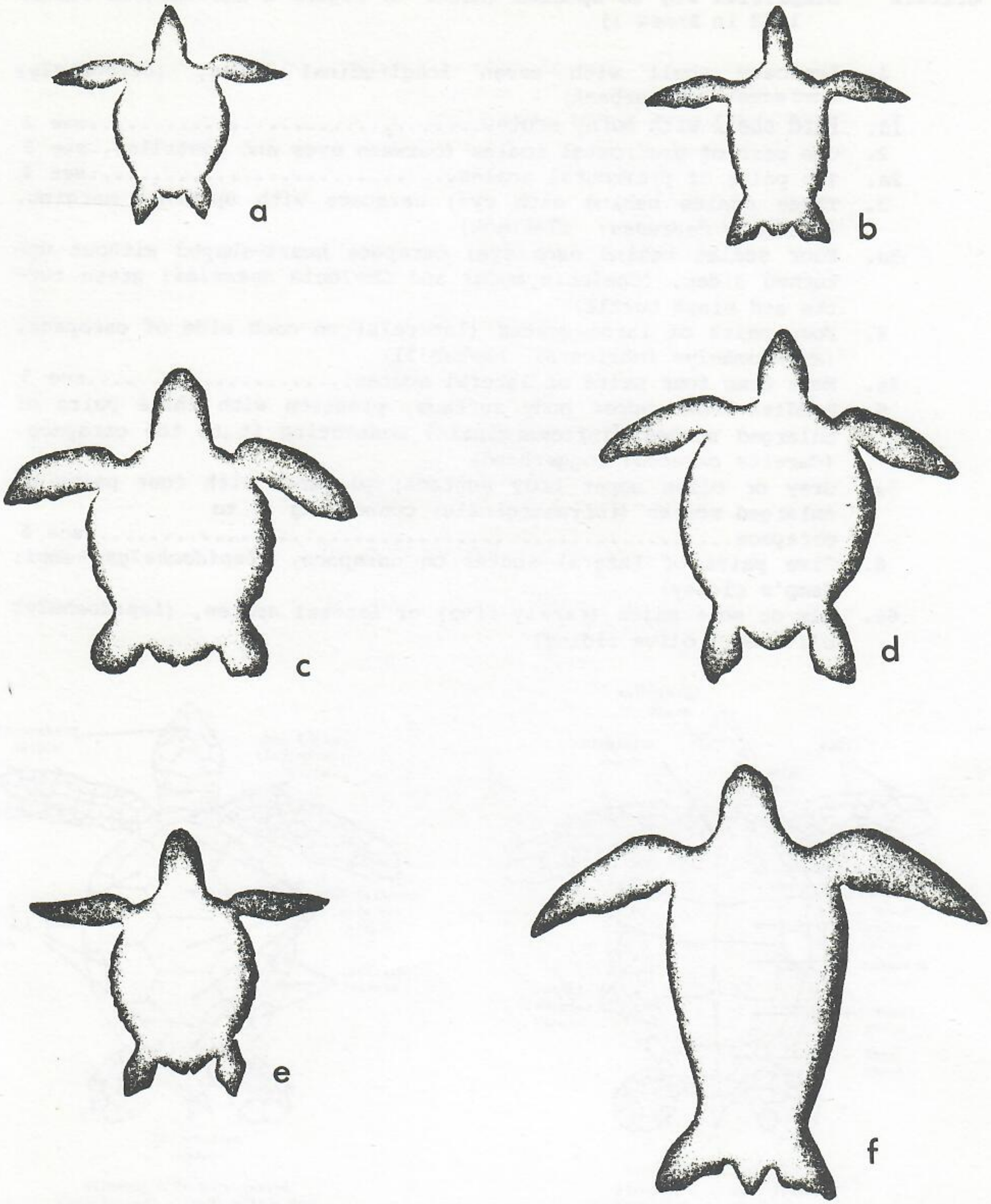


Figure 1. Silhouettes of sea turtles viewed from the air; a relative scale is used. 1,a: *Lepidochelys kempi* (Kemp's ridley) and *L. olivacea* (olive ridley); 1.b: *Eretmochelys imbricata* (hawksbill); 1,c: *Caretta caretta* (loggerhead); 1,d: *Chelonia mydas* (green turtle); 1,e: *Chelonia depressa*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

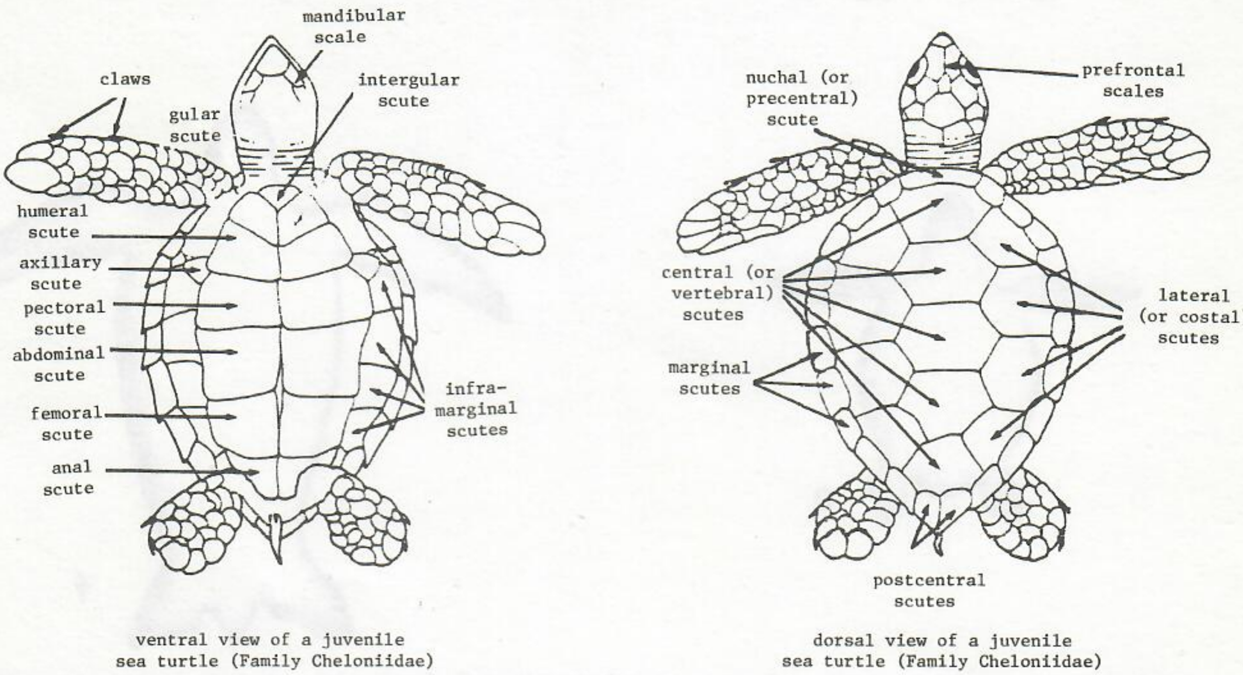


Figure 2. An illustrated guide to morphological terms. *Modified from:* Fischer, W. (Ed.). (1978). *FAO Species Identification Sheets for Fisheries Purposes*. Western Central Atlantic (Fishing Area 31), Vol. VI.

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

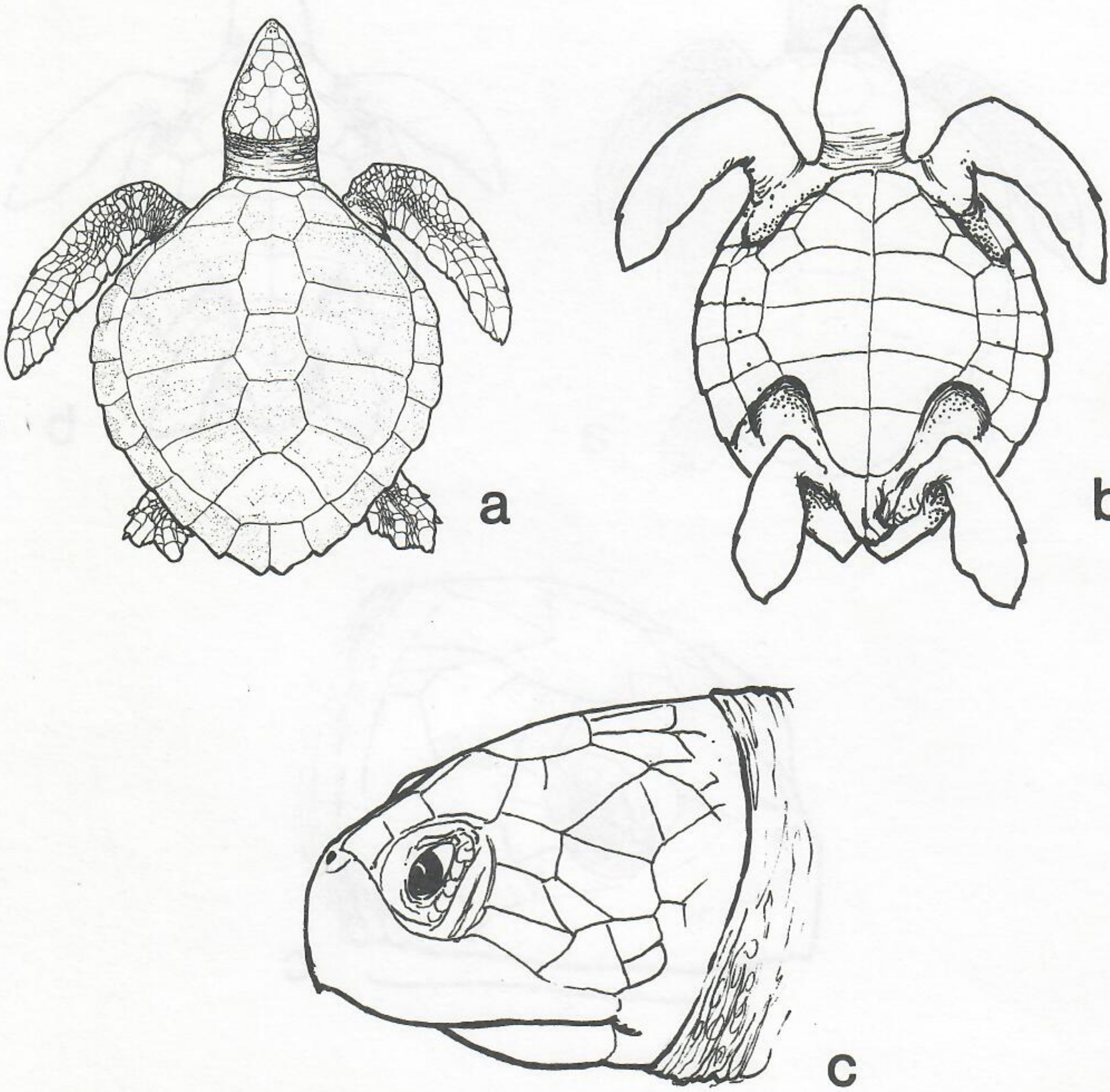


Figure 3. *Lepidochelys kempi* (Kemp's ridley), 3,a: dorsal view; 3,b: ventral view; 3,c: head view.

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

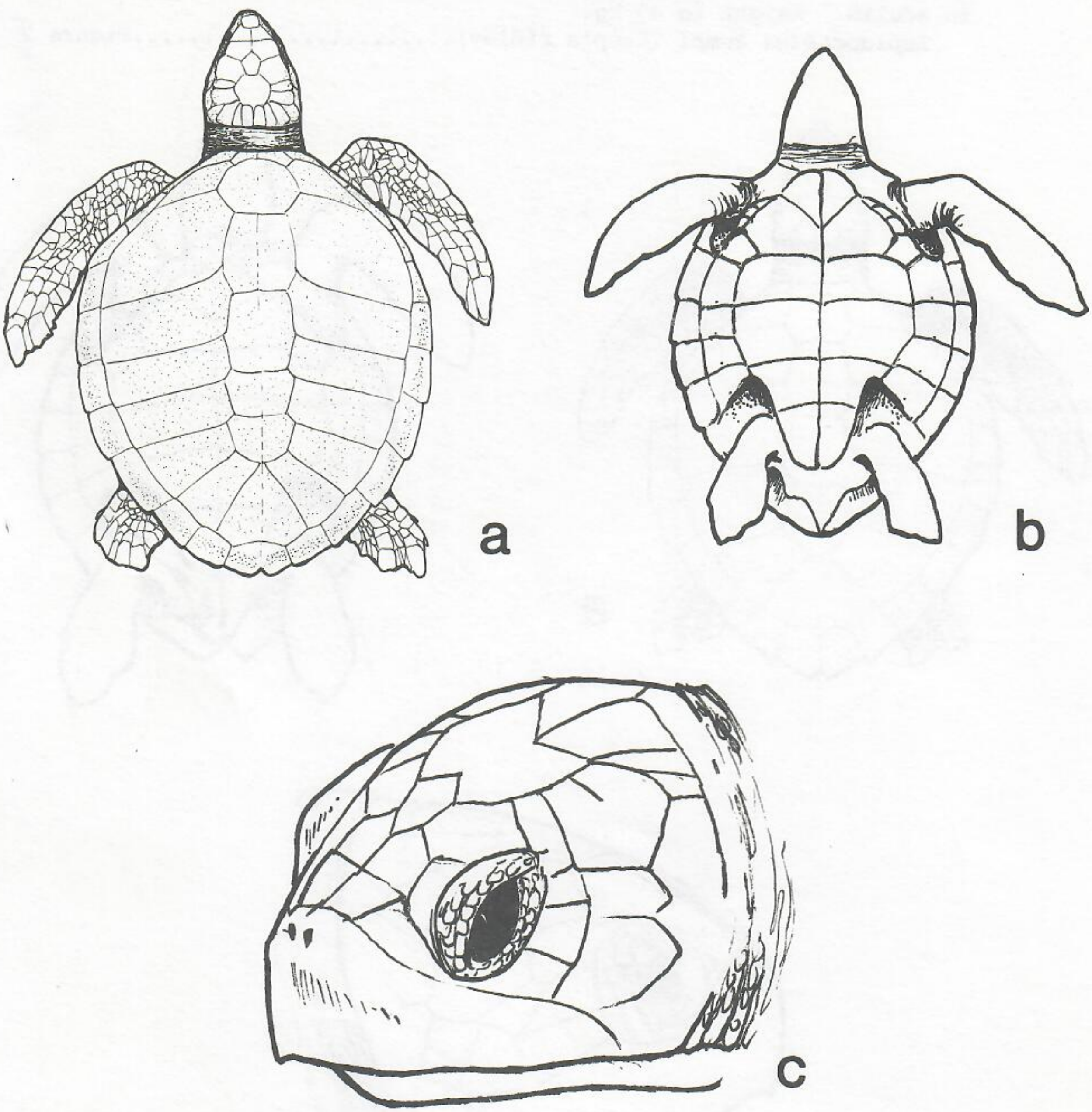


Figure 4. *Lepidochelys olivacea* (olive ridley); 4,a: dorsal view; 4,b: ventral view; 4,c: head view.

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

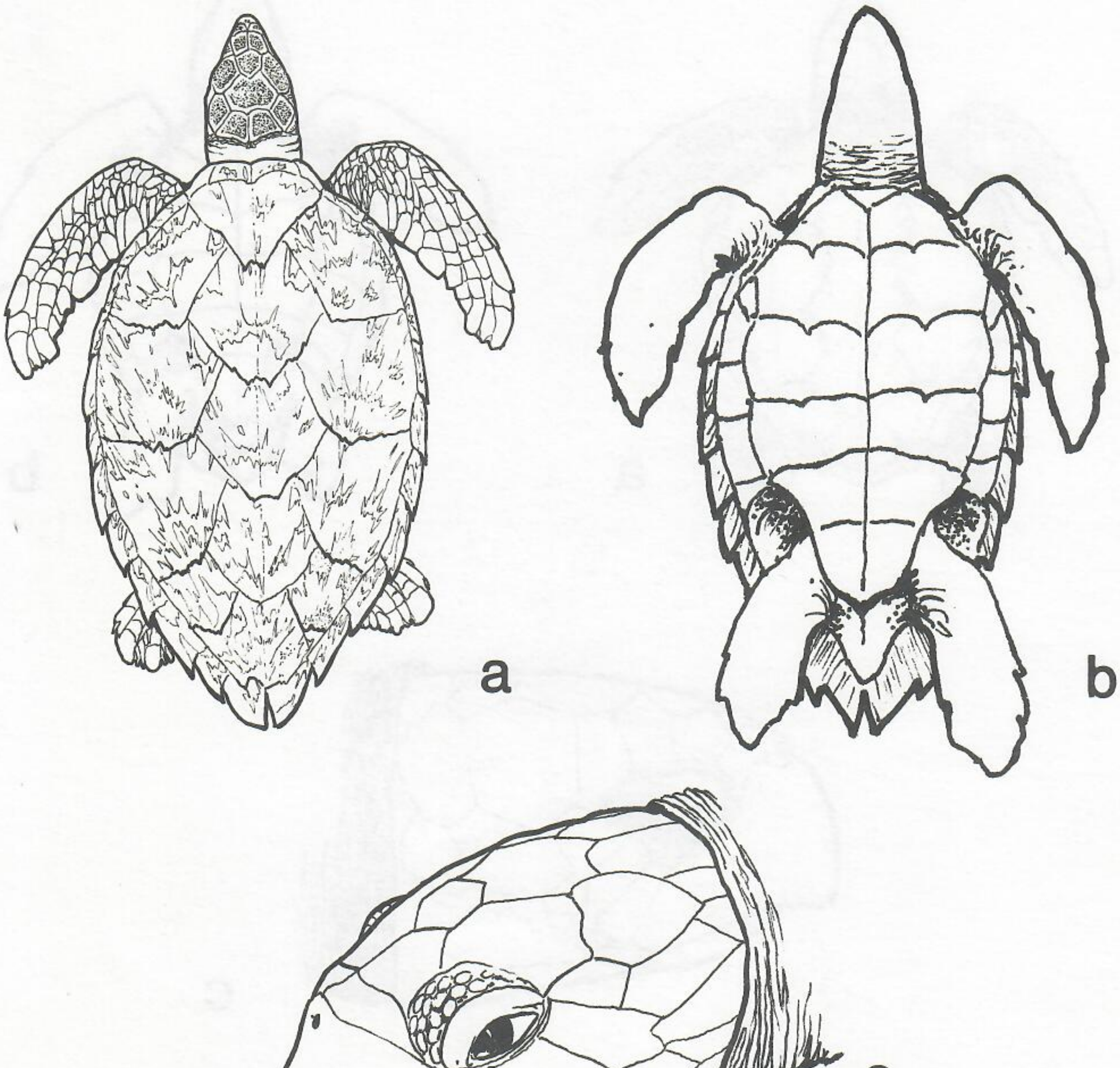


Figure 5. *Eretomochelys imbricata* (hawksbill); 5,a: dorsal view; 5,b: ventral view; 5,c: head view.

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

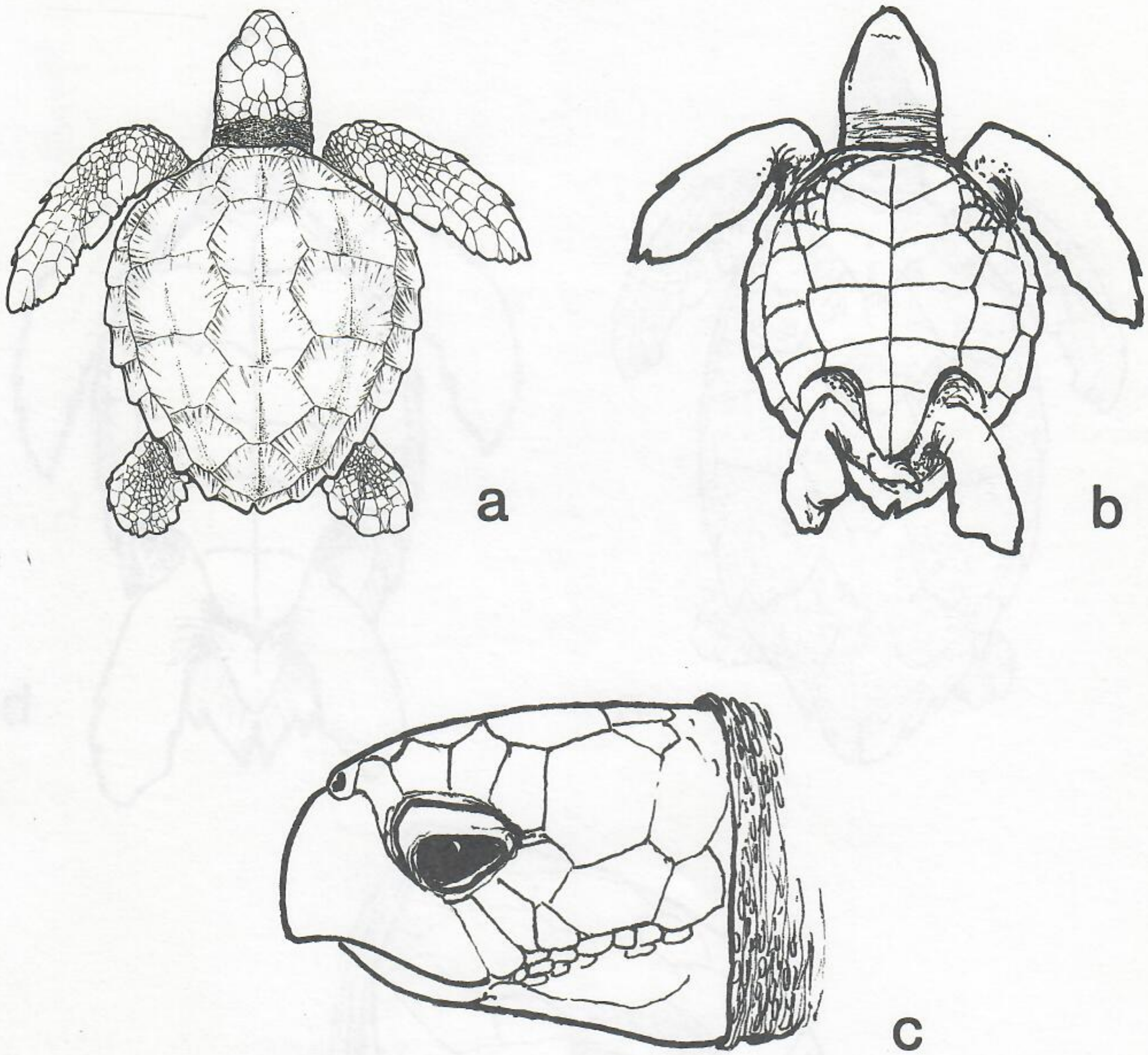


Figure 6. *Caretta caretta* (loggerhead); 6,a: dorsal view; 6,b: ventral view; 6,c: head view.

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

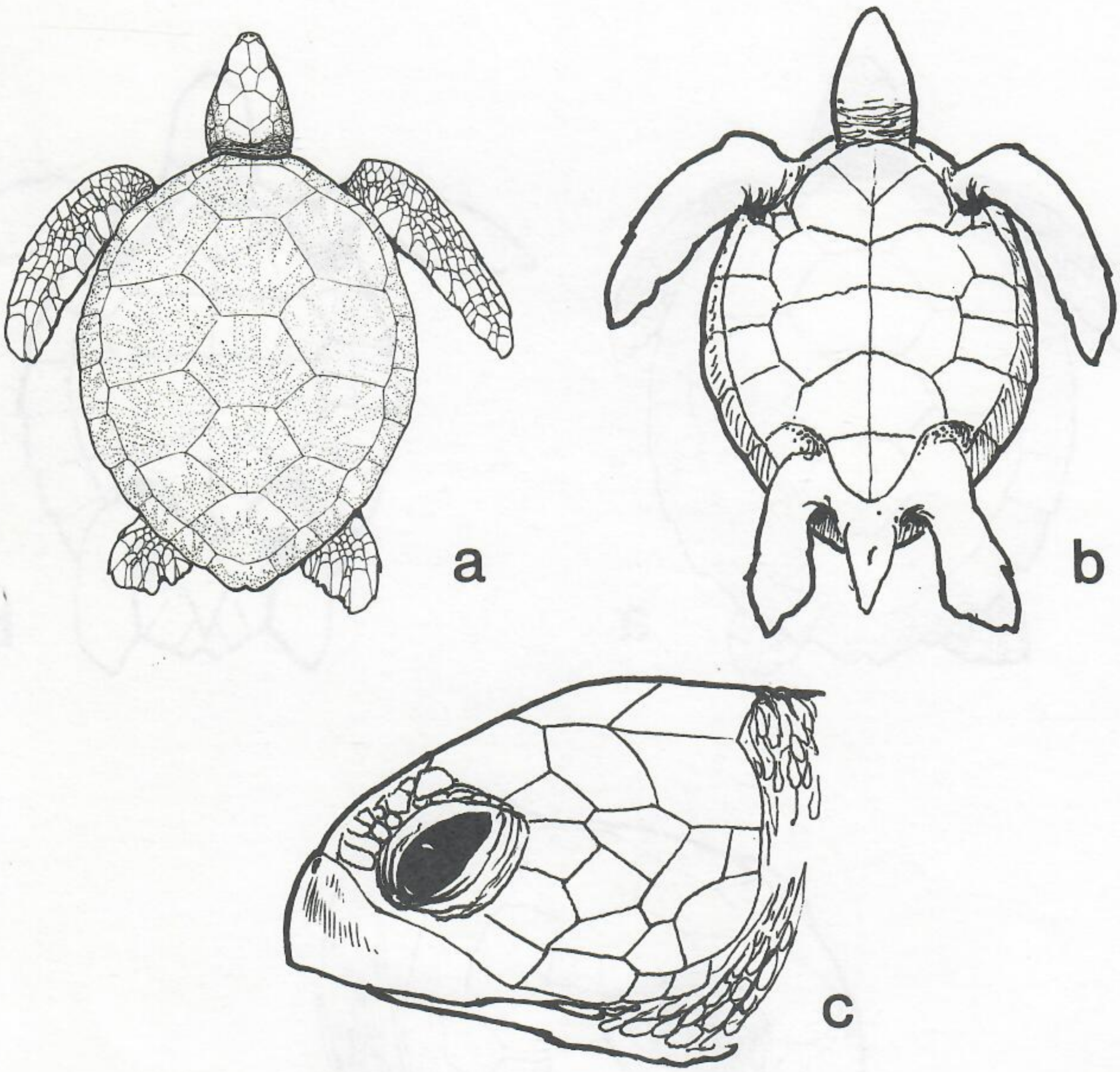


Figure 7. *Chelonia mydas* (green turtle); 7,a: dorsal view; 7,b: ventral view; 7,c: head view.

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

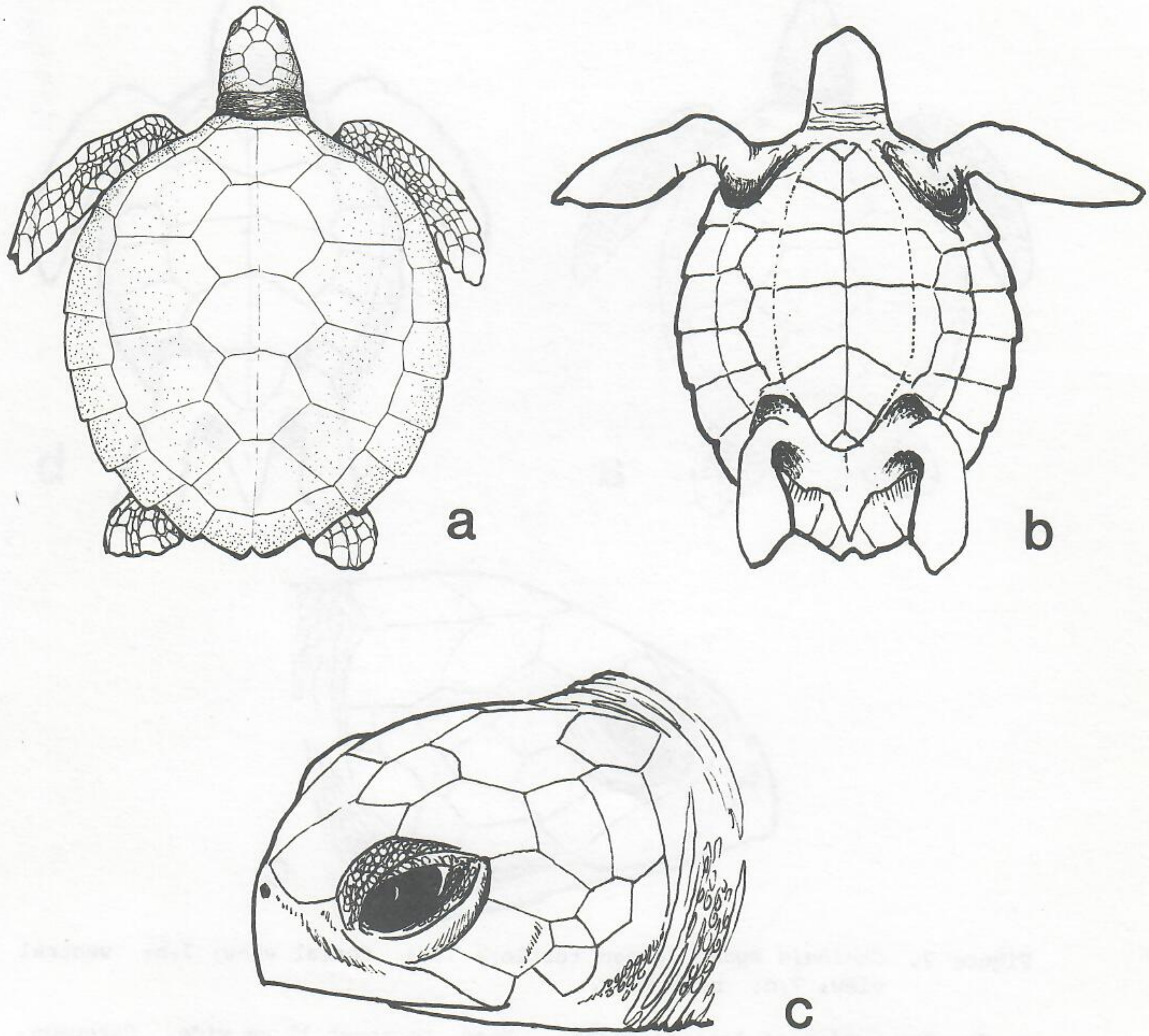


Figure 8. *Chelonia depressa* (flatback); 8,a: dorsal view; 8,b: ventral view; 8,c: head view.

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

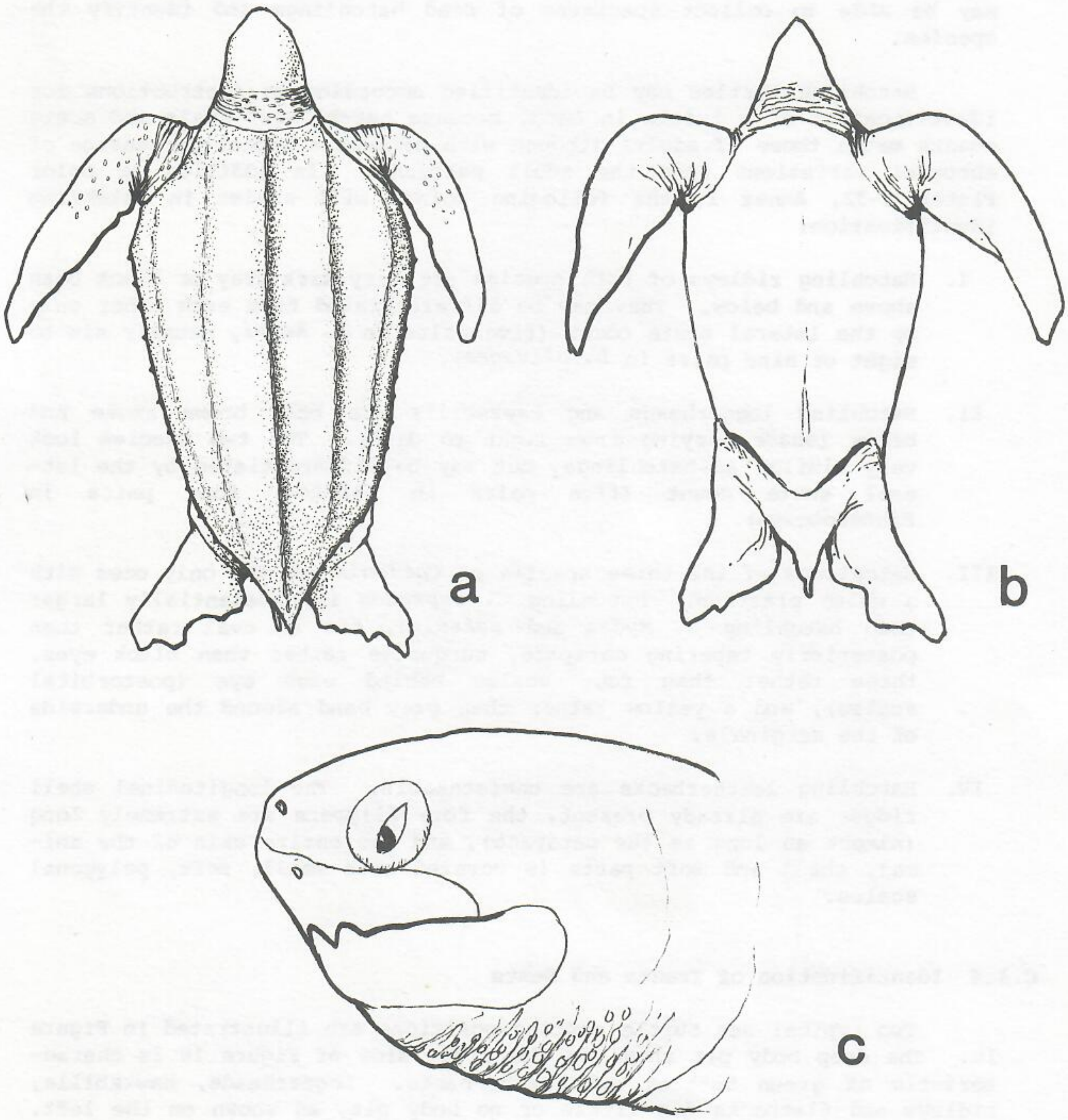


Figure 9. *Dermochelys coriacea* (leatherback), 9,a: dorsal view; 9,b: ventral view; 9,c: head view.

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.

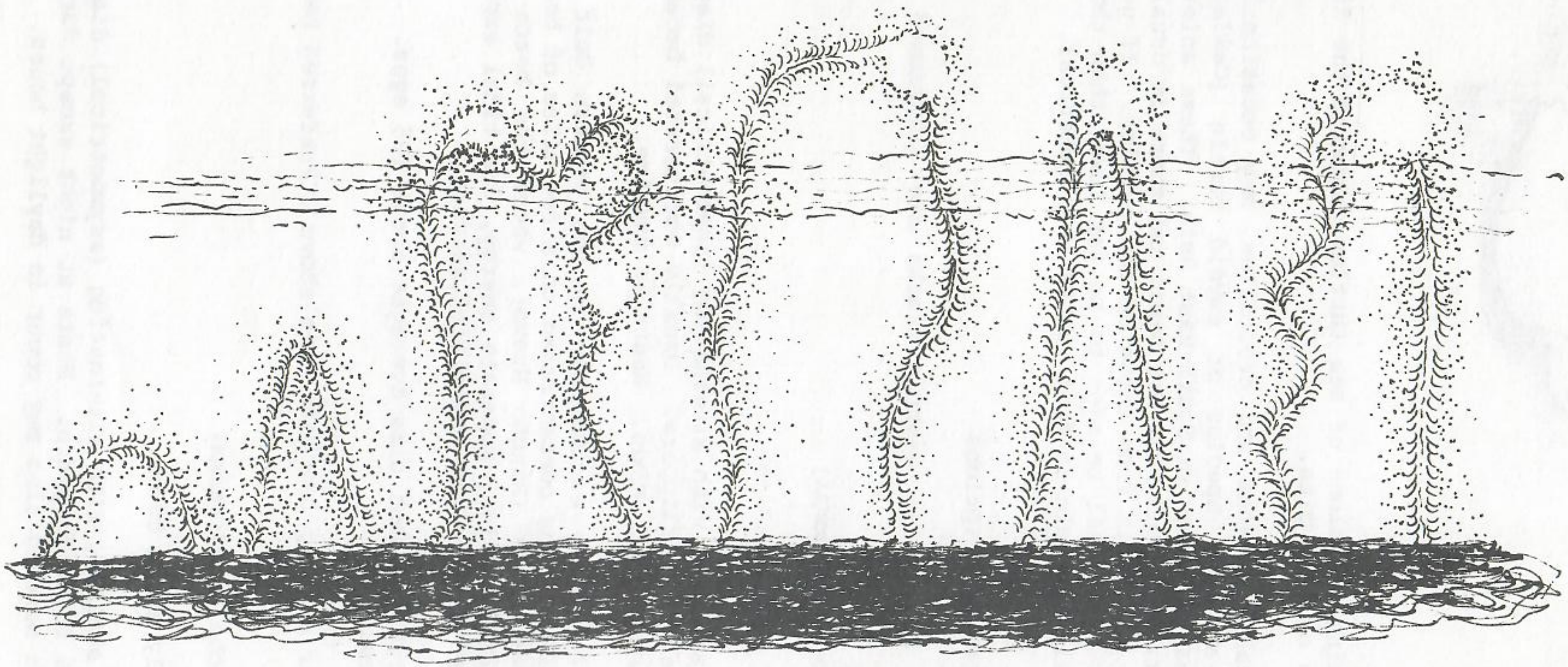


Figure 11. Various types of sea turtle crawl tracks and nest marks to be seen on sandy beaches.

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 Start	End	Distance KM-NM	Lat.	Long.	Zone Heading	Shoreline Characters

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 Number/Name	TIME			NUMBER OF CRAWLS											
				FRESH			OLD			Age Uncertain					
	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

Page 1 of 25

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 O 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 3A

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	Time	Observer #1						Observer #2						Other Data
		Fresh						Fresh						
Name or Number	Start End	Nest	False	Unk.	Old	Total	Species	Nest	False	Unk.	Old	Total	Species	(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 <u>essential</u> for the third type of aerial beach survey (population estimate). <u>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.</u>

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 <u>before</u> 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 Nest	Fresh False	Fresh Unk.	Fresh Total	Old Nest	Old False	Old Unk.	Old Total	Gr. 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 Nest	Fresh False	Fresh Unk.	Fresh Total	Old Nest	Old False	Old Unk.	Old Total	Gr. 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: Nest	Track Location: False	Track Location: Unknown	Age	Track Description
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.

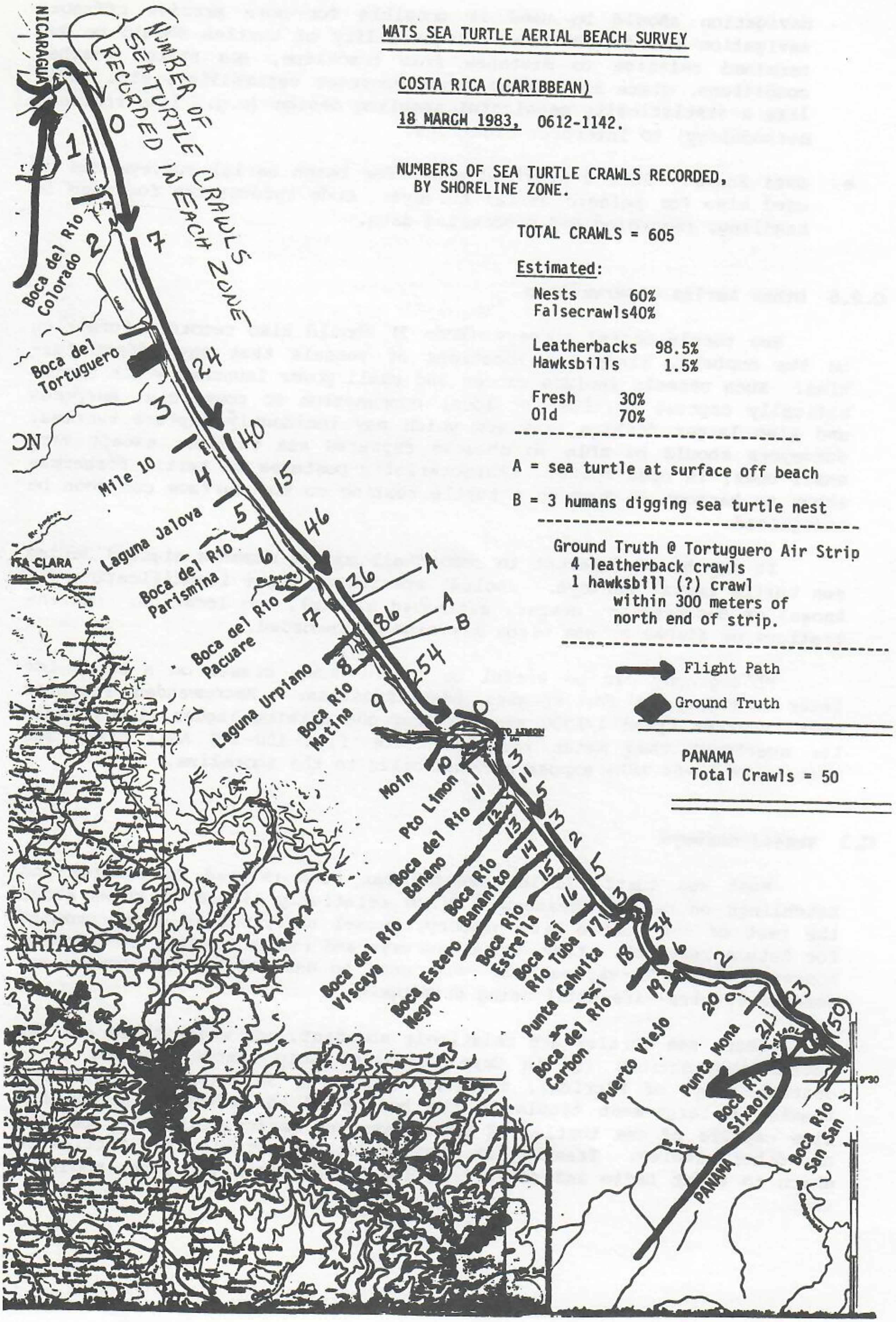
The following is a list of general aspects of pelagic aerial surveys and some suggested guidelines.

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%
Falsecrawls40%
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
NUMBER OF SEA TURTLE CRAWLS RECORDED IN EACH ZONE
NICARAGUA
Boca del Rio Colorado
Boca del Tortuguero
Mile 10
Laguna Jalova
Boca del Rio Parismina
Boca del Rio Pacuare
Laguna Urpiano
Boca Rio Matina
Moin
Pto Limon
Boca del Rio Banano
Boca Rio Bananito
Boca del Rio Viscaya
Boca Estero Negro
Boca Rio Estrella
Boca del Rio Tuba
Punta Cahuita
Boca del Rio Carbon
Puerto Viejo
Punta Mona
Boca Rio Sixaola
Boca Rio San San
PANAMA
CARTAGO

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	Width	Sex	Cond.	Marks	Release Lat.	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).

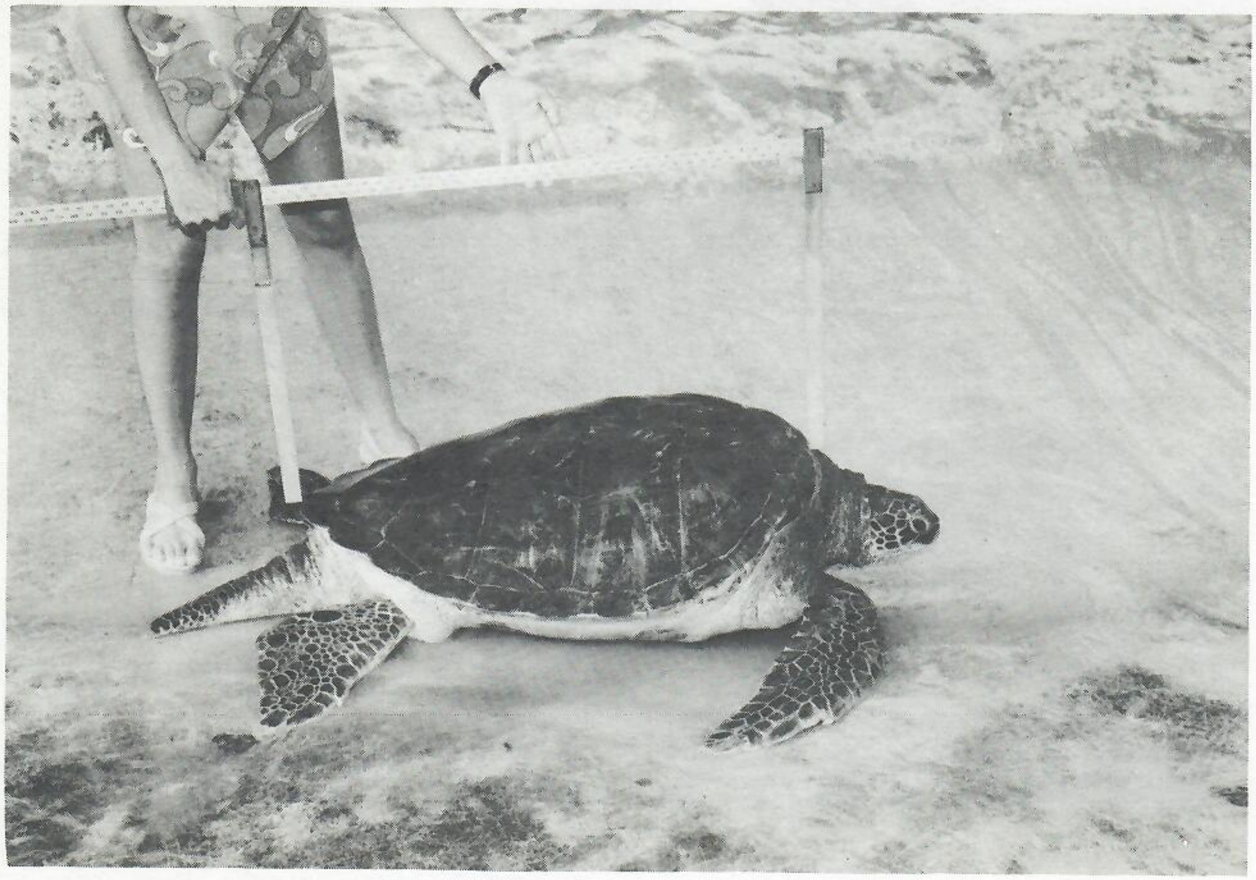


Figure 12. Measuring carapace length: straight-line method using calipers (recommended method). Photo by G. H. Balazs.

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.

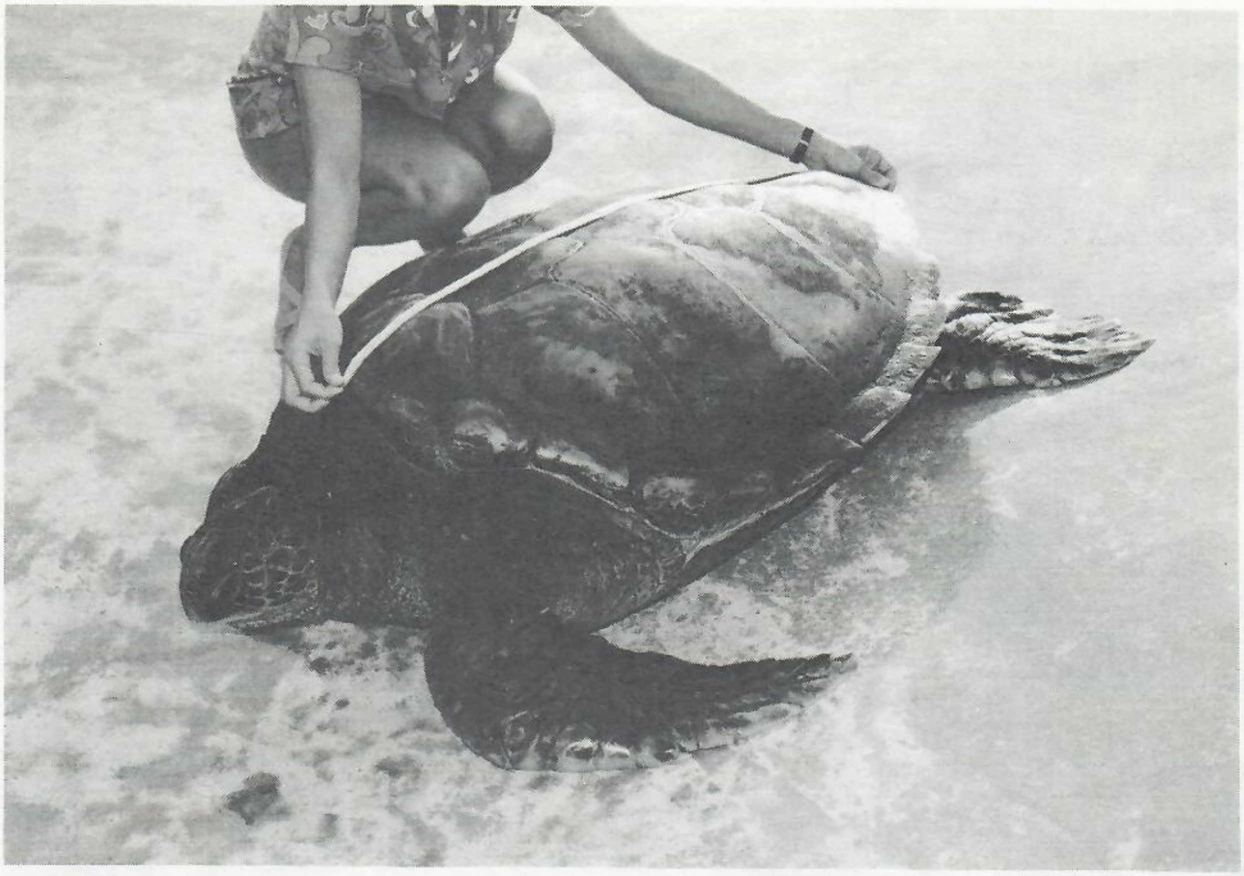


Figure 13. Measuring carapace length: curved-line method, using flexible tape. Photo by G. H. Balazs.

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). <u>Standard carapace length is recommended</u> (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.

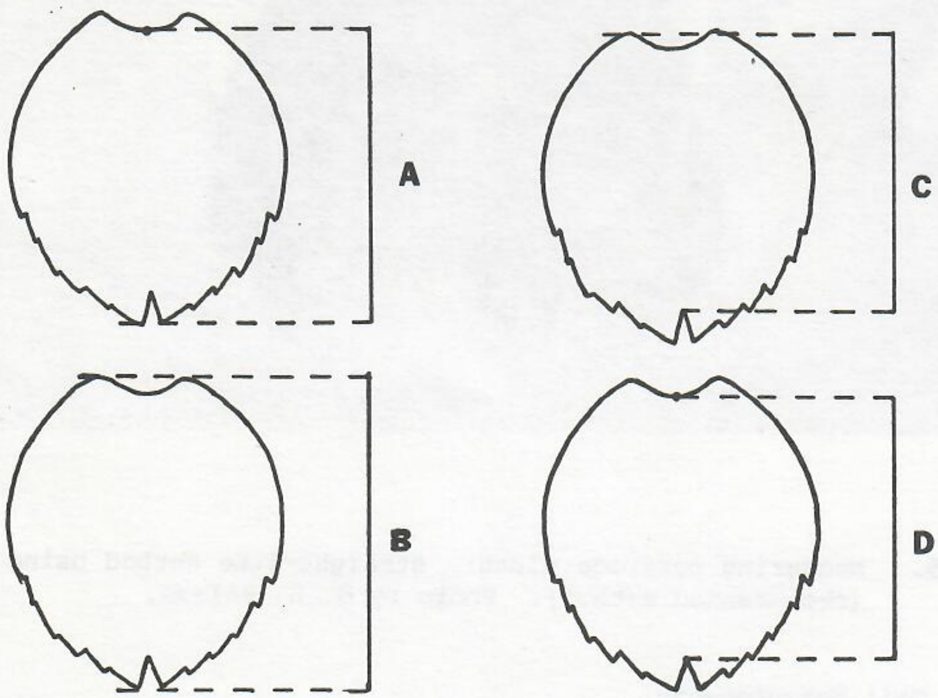


Figure 14. Four sets of anatomical points for measuring carapace length; A is preferred (see C.4.2.3).

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.

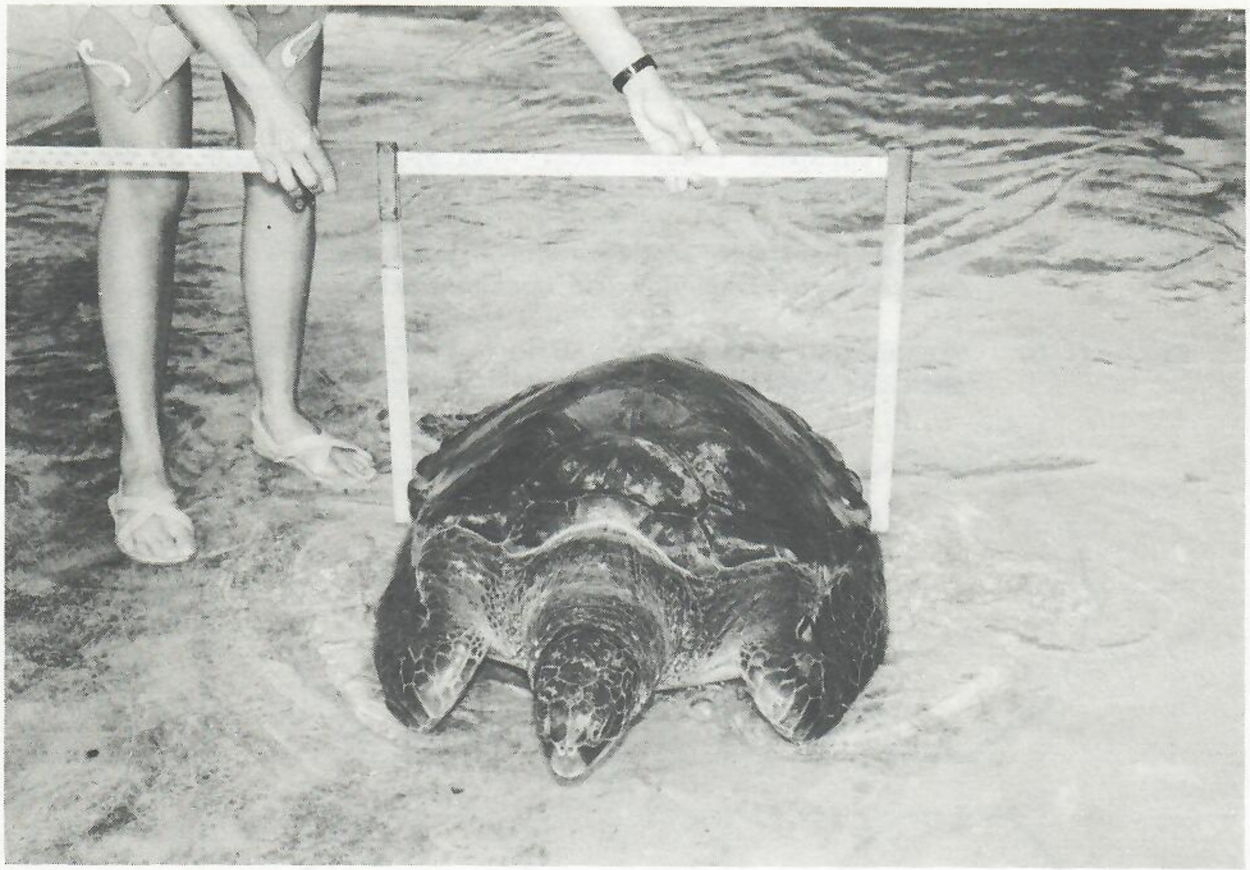
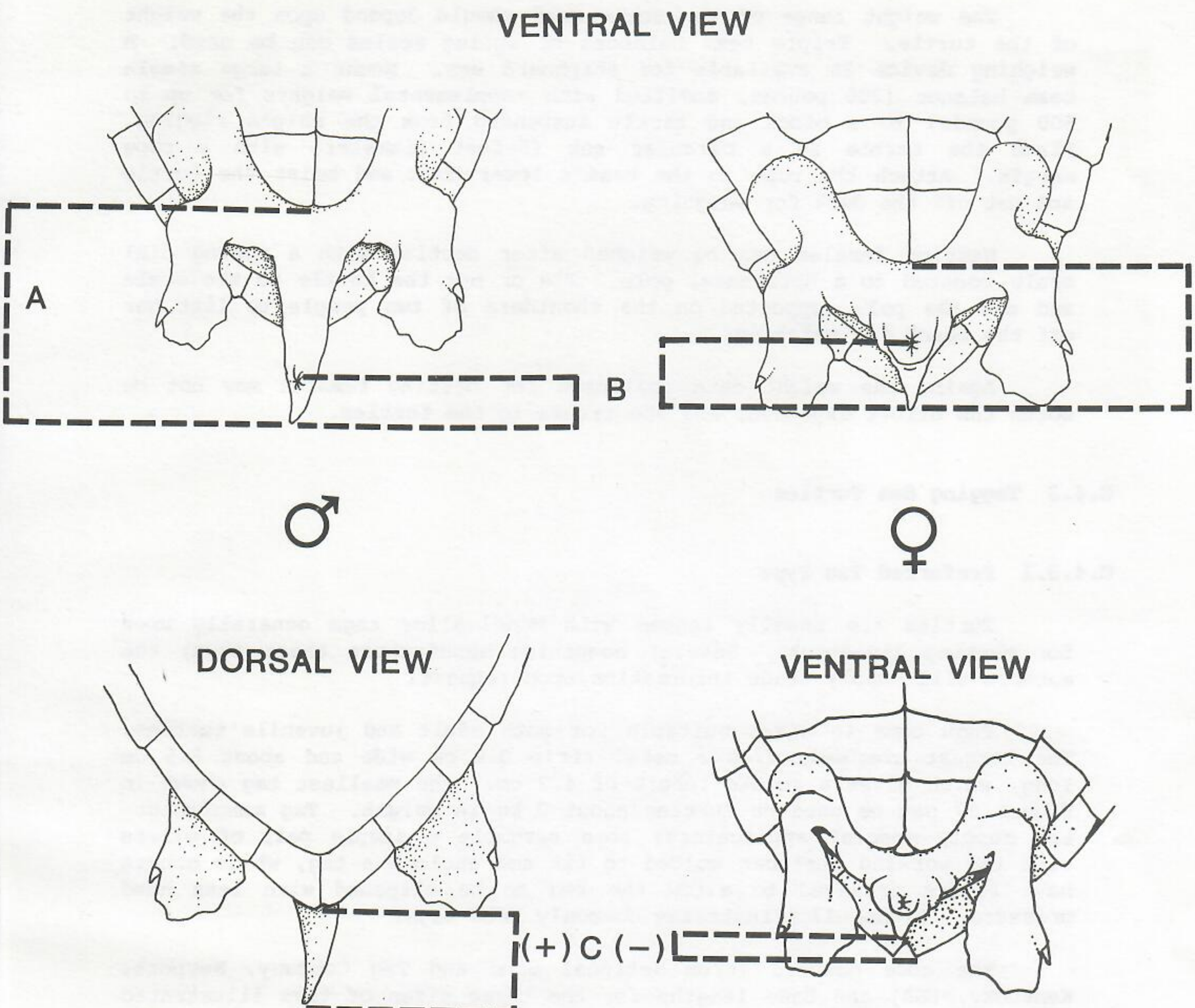


Figure 15. Measuring carapace width: straight-line method using calipers (recommended method). Photo by G. H. Balazs.

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.