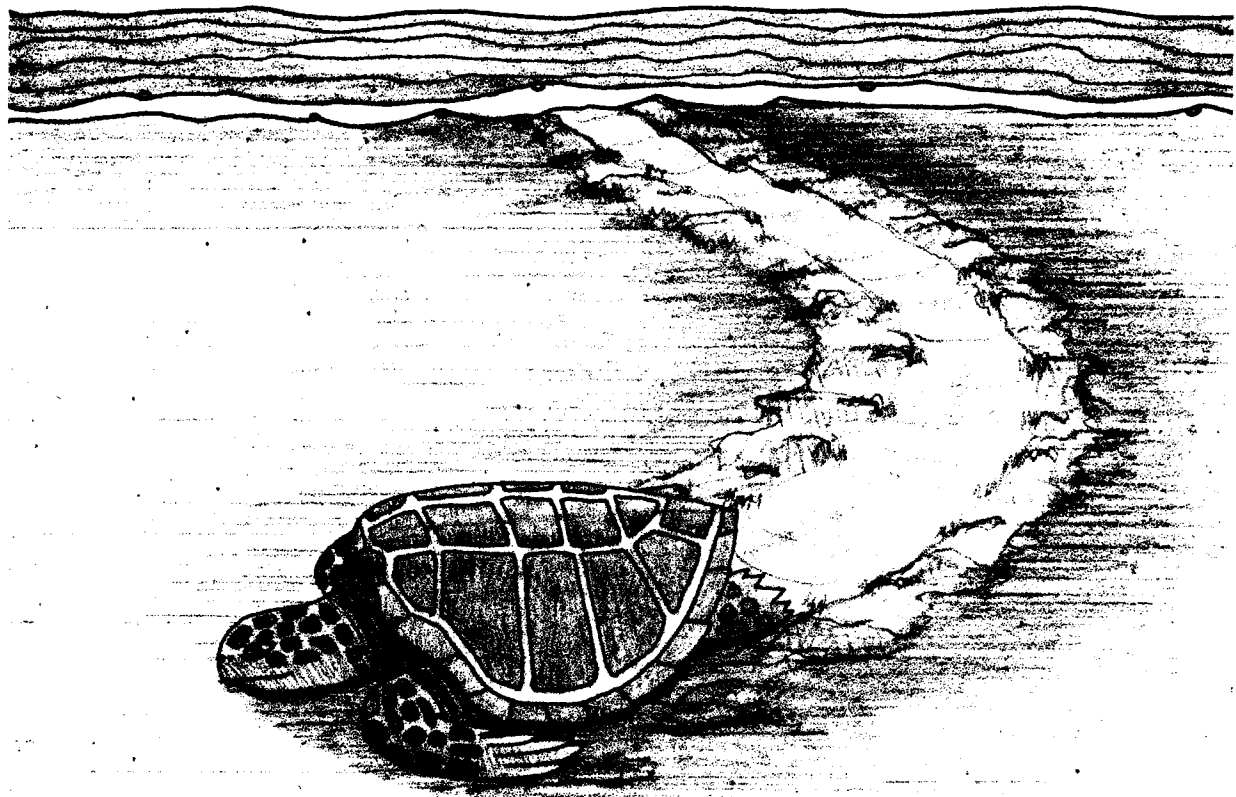


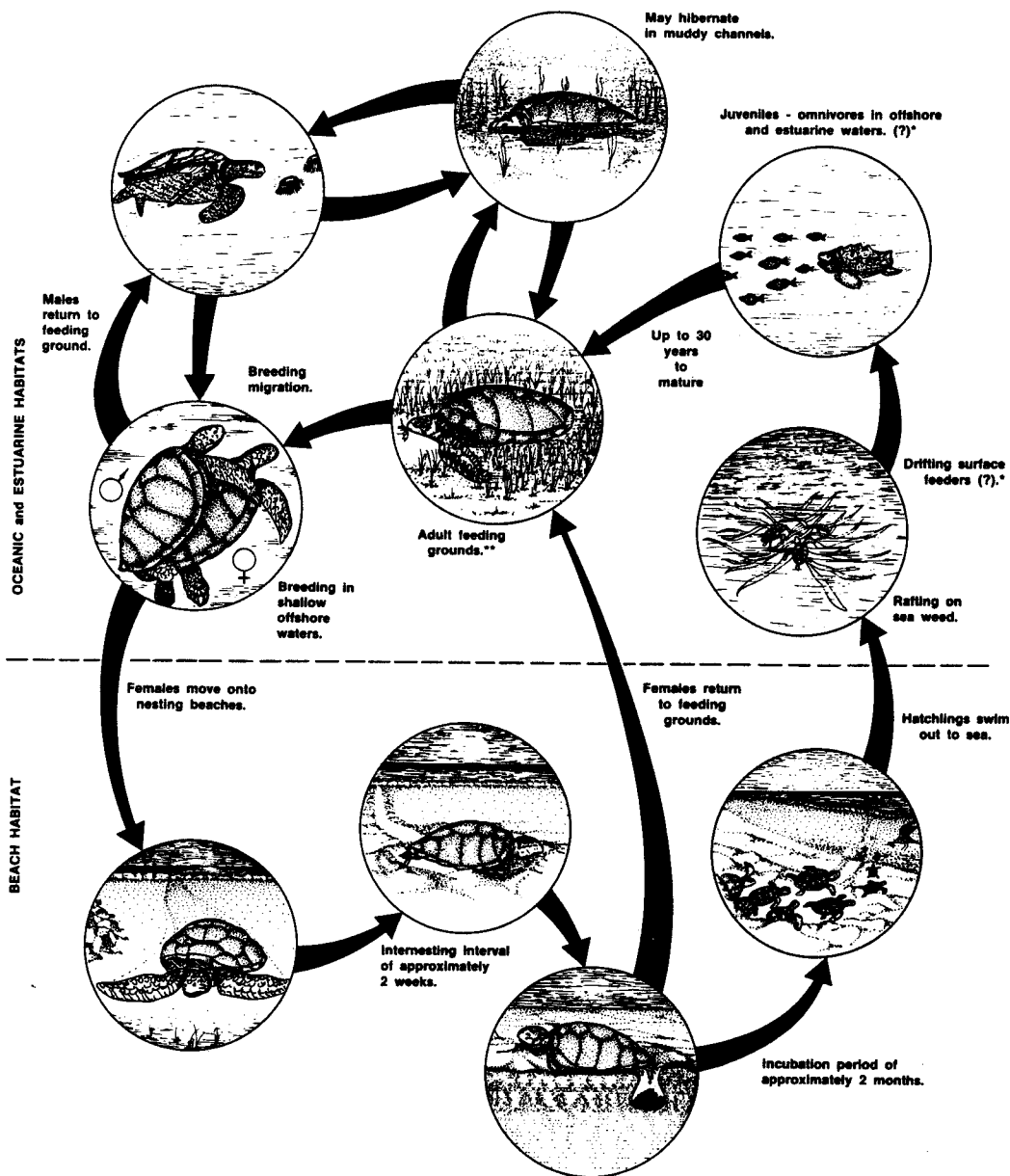


LIFE HISTORY AND
ENVIRONMENTAL
REQUIREMENTS OF
LOGGERHEAD
TURTLES



Fish and Wildlife Service

U.S. Department of the Interior



* Developmental habitats are not well known and probably vary with species.
 ** Feeding habits depend on species.

Figure 6. Diagram of general life cycle of sea turtles (adapted from Mrosovsky 1983).

onto her carapace with his four limbs. The male's 8-inch (20-cm) or longer tail, which is much longer than the female's, is bent downward, thereby pressing his cloacal opening against the female's cloaca (Caldwell 1959).

Nesting

On Hutchinson Island, FL, nesting begins in the spring (April or usually May) when local water temperatures reach 23 to 24 °C (Williams-Walls

et al. 1983), increasing with increased temperatures and photoperiod to a peak in June and July, and declining until completion in late summer (August-September) (Fletemeyer 1981, 1982, 1983; Stoneburner 1981; Richardson and Richardson 1982).

Loggerhead females generally nest every other year or every third year, although a small percentage nest at intervals of less than 2 or more than 3 years (Richardson and Richardson 1982; Bjorndal et al. 1983; Ehrhart and Raymond 1983; Fletemeyer 1983). When a loggerhead nests, it usually will lay 2 to 3 clutches (range, 1 to 7) of eggs per season (Table 2) (Ehrhart 1979; Talbert et al. 1980; Fletemeyer 1981; Lenarz et al. 1981; Richardson and Richardson 1982). The maximum number of clutches laid in a single season by an individual is

probably determined by the duration of the nesting season and by physiological constraints which require 2 weeks for eggs to mature for each successive clutch (Frazer and Richardson 1986). These intraseasonal nestings are generally 12 to 14 days apart (range 11 to 20 days) (Fletemeyer 1983; Williams-Walls et al. 1983; Frazer 1984). Intraseasonal nesting intervals may vary with ambient water temperature. As water temperature increases, the interval between clutches may decrease (Hughes and Brent 1972). A 2-week-long cold water intrusion off Hutchinson Island, FL, lowered the mean surface temperature 3.7 °C, from 29.4 to 25.7 °C. The mean intraseasonal renesting interval was increased from 13.4 to 17.5 days as a result of the decrease in ambient water temperature (Williams-Walls et al. 1983). Loggerheads are not

Table 2. Summary of breeding information on sea turtles. (Conant 1975; Marquez 1978; Marquez et al. 1982; Hopkins and Richardson 1984).

Species	Egg diameter (cm)	Number of eggs	Number of clutches	Nest depth (cm)	Hatchling carapace length (cm)	U.S. season
Leatherback	5.1-6.3	50-170 (92-110) ^a	1-9 (5-6) ^a	75-100	5.5	Mar-Sep
Green	4.5-5.0	100-200 (100)	1-8 (3-7)	75-100	5.0	Jun-Sep
Loggerhead	3.5-4.9	35-180 (120)	1-7 (2-3)	45-90	4.5	Apr-Sep
Kemp's ridley	3.8-4.0	50-185 (110)	2-3	4-35	4.2	Apr-Jul
Hawksbill	3.5-4.0	50-250 (160)	1-4 (2+)	50-60	4.5	May-Aug

Species	Incubation length (days)	Interval between nests (days)	Nesting frequency (years)	Age at maturity (years)	Estimated number of nests/year ^b
Leatherback	50-70	9-17 (9-10) ^c	2-3	—	43
Green	45-60	10-15 (14)	2-4 (2)	20-30 (4-13) ^d	204
Loggerhead	46-65	11-20 (12-14)	2-3 (2.5)	6-30 (30)	29,759
Kemp's ridley	45-70	20-28	2-3 (1)	5-7	<1
Hawksbill	45-75	14-27 (19)	1-4 (3)	3-5	2

^aNumbers in parentheses equal average or common number or value reported in literature.

^bU.S. continent. Information from Gordon (1983).

^cCommon number of days between nests.

^dCommon age at maturity (age at maturity is largely based on animals raised in captivity).

considered to be as site specific when returning to a nest between or within seasons as are green sea turtles (Caldwell et al. 1959; Talbert et al. 1980; Bjorndal et al. 1983). Distance between nest sites of a particular turtle during a season (re-nesting distance) is generally less than 5 km (Hughes 1974; LeBuff 1974; Ehrhart 1979; Williams-Walls et al. 1983; Talbert et al. 1980; Fletemeyer 1983); the longest known interesting distance interval is 700 km (Stoneburner and Ehrhart 1981).

Beach selection for nesting may be based on repeated use of the same nest site (Carr 1967; Richardson and Richardson 1982; Fletemeyer 1983; Hopkins and Richardson 1984), learned behavior (Hendrickson 1958), position of beach rocks (Hughes 1974; Mann 1978), and proximity of offshore reefs (Stoneburner 1982; Williams-Walls et al. 1983). Loggerheads may return to a beach to nest because of (1) nest site fixity, or (2) inheritance of the ability to return to a particular beach, together with imprinting at birth to a beach. Rock outcrop on the shoreline may serve to guide turtles to a certain beach in Africa (Hughes 1974) while, in the United States, rocks which are narrowly spaced may reduce the use of a beach for nesting (Mann 1978). Beaches close to offshore reefs are used more frequently for nesting. Offshore reefs are used for resting and feeding areas between egg-laying sessions (Stoneburner 1982; Williams-Walls et al. 1983).

Loggerheads emerge from the surf at night and crawl ashore (Frazer 1983b). Approximately 30%-50% of the time they crawl onto the beach (sometimes excavating a cavity, sometimes not) and return to the water without depositing eggs (false crawl) (Stoneburner 1981; Ehrhart and Raymond 1983; Williams-Walls et al. 1983). The reasons for these "false crawls" are not well understood but may be influenced by a turtle's "readiness" to lay, physical

properties of the beach, temperature of the beach sand, and disturbance of the emerging turtle (Mann 1978; Fletemeyer 1981; Stoneburner and Richardson 1981; Ehrhart and Raymond 1983). Sand which is too firm may inhibit or prevent turtles from digging nests; sand may be compacted by vehicular traffic on the beach or beach nourishment (Fletemeyer 1981; Ehrhart and Raymond 1983; Williams-Walls et al. 1983). Emerging turtles that encounter human or animal activity or lights shining directly onto the beach may return to the water without nesting (Mann 1978; Fletemeyer 1979; Ehrhart and Raymond 1983). Moving lights, such as from automobiles, may also deter nesting in some locations (Mann 1978).

Loggerheads usually locate their nests between mean high tide and the top of the primary dune, most often at the seaward base of the dune. Each female turtle may dig in one to five spots before finally laying (Ehrhart and Raymond 1983). Nest-digging and egg-laying usually take about 1 h. Between 35 and 180 eggs ($\bar{x}$ = 120) are deposited into the nest hole (Fletemeyer 1983, Hopkins and Richardson 1984). In Georgia and Florida, loggerhead clutch size does not significantly increase or decrease monotonically for sequential clutches by an individual over the course of a nesting season (Ehrhart 1980, Frazer and Richardson 1985). However, clutch size does increase with individual straight-line (SL) carapace length (Ehrhart 1980, Frazer and Richardson 1986). The nest site usually has a very shallow depression or body pit. The depth of the flask-shaped nest from the beach surface to the bottom of the eggs ranges from 43 to 86 cm ($\bar{x}$ = 58.7 cm, SD = 7.92 cm). The vertical thickness of egg mass ranges from 10 to 40 cm ($\bar{x}$ = 23 cm, SD = 6.5 cm) (Limpus et al. 1979). The nest cavity is 20.3 to 25.4 cm wide (Caldwell 1959). The depth from the beach surface to the top of the eggs ranges from 12.7 to 55.9 cm but most often is 27.9 to 40.6 cm.

Eggs

Loggerhead eggs are slightly smaller but similar in appearance to ping-pong balls (Figure 7). No air space is present in the eggs, and the shells, although calcareous, are soft and pliable (Ackerman 1980). Pore structure is absent in the mineralized layer of the turtle egg shell (Solomon and Baird 1976). The eggs range from 35 to 49 mm in diameter, averaging 42 mm (Caldwell 1959; Caldwell et al. 1959; Ehrhart 1977, 1979; Hirth 1980). Average egg weight is 38.4 g (Kaufmann 1968). Egg size tends to be smallest for eggs laid last within a nest (Caldwell 1959). Egg size in loggerheads apparently does not change substantially with body size, clutch size, or date clutch is laid (Frazer and Richardson 1986). Small, yolkless eggs 28 to 30 mm in diameter may also be laid (Caldwell 1959; LeBuff and Beatty 1971).

The eggs hatch in 46 to 65 days ($\bar{x}$ = 60 days) and hatchlings emerge from the nest 2-3 days later; much of the predation on hatchlings occurs during that 2-3 day period (Ackerman 1981; Yntema and Mrosovsky 1982; Fletemeyer 1983; Hopkins and Richardson 1984).

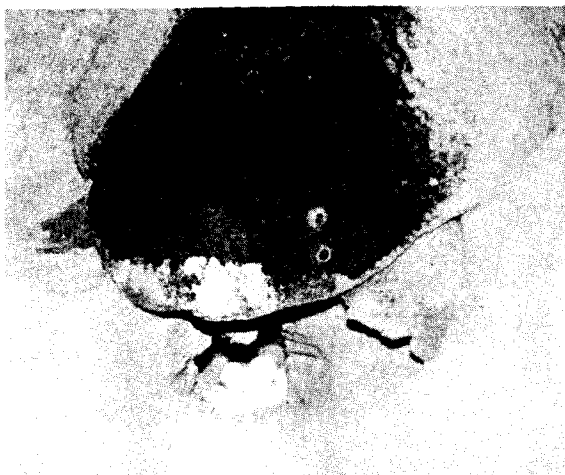


Figure 7. Exposed clutch of eggs being deposited by a loggerhead turtle.

In Florida, and probably other warmer climates, the incubation period tends to be shorter (53 days, SD = 2.6, Nelson et al. 1986). Hatching success or fertility rates in natural clutches are 80% to 90% (Ehrhart 1982) (Figure 8). Hatching success and incubation time can be affected by clutch size, ambient sand temperature, sand compaction, and other physical parameters of the sand surrounding the nest (Mann 1978; Fletemeyer 1979; Yntema and Mrosovsky 1982; Limpus et al. 1983b). As the clutch mass increases, the incubation time increases (Ackerman 1980). The higher the ambient sand temperature, the shorter the incubation time. However, eggs do not hatch when exposed to ambient sand temperatures outside the 24 to 34 °C range. Optimal hatching success occurs between 25 and 32 °C (Limpus et al. 1983b). During the critical period of 11 to 31 days of incubation, when incubation temperatures were laboratory-controlled and constant at 32 °C or above, all embryos developed into females, whereas at 28 °C or below all embryos developed into males; at 30 °C embryos developed into relatively equal numbers of males and females (Yntema and Mrosovsky 1982).

Eggs consume oxygen throughout their incubation. The rate of oxygen uptake increases rapidly during the second half of incubation and slows slightly just prior to hatching (Ackerman 1981). Adequate exchange of oxygen and other gases between the nest and surrounding sand is important to the rate of growth and viability of the embryos (Ackerman 1980). Gas exchange can be affected by grain size and moisture content of sand (Hillel 1971). Sands that range from fine to coarse (0.25- to 0.125-mm size grains) allow sufficient gas exchange for high hatching success (Schwartz 1982). Sand compaction may also affect gas exchange (Fletemeyer and Beckman, in press). Compacted sands, which may result from vehicular traffic on the beach and beach nourishment, may also inhibit the digging by hatchlings from



Figure 8. Hatching success being determined for a loggerhead nest in Delray Beach, Florida.

the nest cavity to the sand surface (Mann 1978; Fletemeyer 1979). Compacted sands may also cause direct egg loss when a nesting cavity cannot be adequately dug to a size to contain all the eggs or to a depth which will give the eggs protection from weather and crushing (Raymond 1984a).

Hatchlings

Hatchlings emerge as a group from the nest at night and orient seaward (Hopkins and Richardson 1984). They crawl upwards from the nest to just below the beach surface and remain there for 1-3 days before emerging (Figure 9). Those that hatch late or remain in the nest after others in the clutch have emerged usually die (Carr and Hirth 1961). Ehrhart and Raymond (1983) found 83% to 90% of the hatchlings in each clutch on some Florida beaches emerged successfully. Recently hatched turtles weigh 15 to

23 grams and measure 44 to 48 mm in carapace length and 35 to 40 mm in carapace width (Caldwell et al. 1955; Fletemeyer 1983) (Figure 10). After emergence, hatchlings must reach the water rapidly to avoid heat stress or predation from gulls, raccoons, and ghost crabs (Dean and Talbert 1975; Hosier et al. 1981); however, gulls and heat stress are not usually factors since most emergences occur at night. Orientation of hatchlings to the ocean has been attributed to geotaxis (no longer an acceptable hypothesis) (Parker 1922), reflected surf light (Daniel and Smith 1947a), and bright horizon pattern (Mrosovsky and Carr 1967; Kingsmill and Mrosovsky 1982). The seaward orientation can be disrupted when lights from structures are directly visible landward from a nest (Mann 1978). Confused by the light shining on the beach, the hatchlings may wander inland and onto adjacent roadways (Mann 1978; Fletemeyer