



OXFORD JOURNALS  
OXFORD UNIVERSITY PRESS

---

Some Problems of Sea Turtle Ecology

Author(s): Archie Carr

Source: *American Zoologist*, Vol. 20, No. 3, Behavioral and Reproductive Biology of Sea Turtles (1980), pp. 489-498

Published by: Oxford University Press

Stable URL: <http://www.jstor.org/stable/3882479>

Accessed: 29/06/2010 02:18

---

Your use of the JSTOR archive indicates your acceptance of JSTOR's Terms and Conditions of Use, available at <http://www.jstor.org/page/info/about/policies/terms.jsp>. JSTOR's Terms and Conditions of Use provides, in part, that unless you have obtained prior permission, you may not download an entire issue of a journal or multiple copies of articles, and you may use content in the JSTOR archive only for your personal, non-commercial use.

Please contact the publisher regarding any further use of this work. Publisher contact information may be obtained at <http://www.jstor.org/action/showPublisher?publisherCode=oup>.

Each copy of any part of a JSTOR transmission must contain the same copyright notice that appears on the screen or printed page of such transmission.

JSTOR is a not-for-profit service that helps scholars, researchers, and students discover, use, and build upon a wide range of content in a trusted digital archive. We use information technology and tools to increase productivity and facilitate new forms of scholarship. For more information about JSTOR, please contact [support@jstor.org](mailto:support@jstor.org).



Oxford University Press is collaborating with JSTOR to digitize, preserve and extend access to *American Zoologist*.

<http://www.jstor.org>

## Some Problems of Sea Turtle Ecology<sup>1</sup>

ARCHIE CARR

Department of Zoology, University of Florida,  
Gainesville, Florida 32611

**SYNOPSIS.** Tagging programs have revealed parts of the patterns of reproductive migration of some sea turtle populations, but much of the ecologic geography of the species remains unknown. The present paper takes stock of the advances and gaps in our knowledge of the group. Kemp's ridley and the Tortuguero green turtle population are used as sources of examples of these strong and weak areas. Possible causes of one-season nesting and its bearing on sea turtle demography are discussed. An apparent dichotomy in the "lost-year" ecology of the Tortuguero green turtles and Kemp's ridley is suggested. Some hatchlings of both evidently drift away in major currents, while others pass this stage circling in local eddies—*Chelonia* in the West Caribbean Gyre and *Lepidochelys kempi* within the Gulf of Mexico.

An impressive feature of the recent World Conference on Sea Turtle Conservation in Washington, D.C., was the manifestation of worldwide interest in sea turtles; another was the elementary state of our knowledge of their ecology. In planning the present paper I had hoped to assess knowledge of the life cycles of the genera by briefly comparing patterns of ecologic station-change. At the conference, people from all around the world were going to report on current research results; and Anne Meylan was preparing a summary of tag recovery data for all the species. The time seemed ripe for a comparative review. It soon became clear, however, that overall ecologic patterns have not yet been revealed.

The chief obstacle has been the numerous habitat shifts that all sea turtles make. Of these, the breeding migrations are the best known, especially those of some populations of *Chelonia*. Most green turtles gather to breed along limited stretches of shore; and being herbivorous, they assemble to feed where good plant forage spreads in continuous tracts. These habits make them accessible for both tagging and exploitation and because the turtles are commercially valuable, assiduous harvest-

ing insures a steady return of recovered tags.

Obviously, such data reveal only end-points and periodicities of migration. Nevertheless, rudimentary patterns of the reproductive travels of a few populations have emerged. As an example, when the tagging program was initiated at Tortuguero, Costa Rica, in 1955, my first aspiration was to test the notion of turtles and fishermen that *Chelonia* makes regular long-range migrations between breeding and feeding places. Extensive post-season travel away from the Tortuguero rookery was soon proved, and proof of philopatry (regional homing) and nest-site fidelity accumulated steadily. Within five years, tag-returns had roughed out a migratory pattern for the colony that has remained basically unchanged until today, when some 1,200 long distance tag-returns have come in.

Because the Tortuguero pattern began to take shape early, when other tagging projects had generated only desultory recovery data, and because the condensed foraging habitat makes it relatively diagrammatic, it has been useful as a model for sea turtle migration. However, to adhere to it slavishly in interpreting the ecological geography of other populations only generates confusion. The same can be said of the station-change diagram shown by Carr *et al.* (1978, Fig. 2), in which boxes and arrows indicate changes in habitat by the Tortuguero population. As a general-

<sup>1</sup> From the Symposium on *Behavioral and Reproductive Biology of Sea Turtles* presented at the Annual Meeting of the American Society of Zoologists, 27-30 December 1979, at Tampa, Florida.

ized scheme this is valid and useful—although Limpus (1980) and Balazs (1980) have embellished it with details suggested by their studies of Australian and Hawaiian turtles.

A weakness in the analysis is the forage-ground box, which to a literal mind suggests that after leaving the nesting ground, sea turtles go straight back to some circumscribed (preferably rectangular) year-around feeding place. A tendency to return to a specific feeding area actually is shared by the other West Atlantic green turtle colonies—those of Aves Island, Surinam, and Ascension Island. Future tagging may show it to be even more widespread among the colonies that feed on turtle grass—which does not thrive along the exposed shores that make good nesting beach. All the other sea turtles are mainly carnivorous, however, and some of their foraging is itinerant. In such cases the feeding habitat diagrammed as a box in the figure is actually an extensive cruising range and this will be represented by ragged patterns of tag-return. When to this factor is added the scant exploitation that most other genera undergo, it should not be surprising that travel patterns emerge only slowly.

Even within the *Chelonia mydas* complex (*mydas* in the Atlantic system; *agassizi* in the eastern and central Pacific; and the possibly valid *carrinegra* on the Pacific coast of Mexico; and the puzzlingly dichotomous representation of the group in other parts of the Indo-Pacific) there are departures from the Carr *et al.* (1978) diagram. Some foraging colonies appear to include both a migratory contingent, and another that nests on beaches adjacent to the feeding grounds (Dampier, 1906; Pritchard, 1971a; Green, 1979; Meylan, 1980a). This suggests that elsewhere, whole residential colonies may find it unnecessary to migrate. Where both feeding and nesting are possible within an area in which winter temperatures remain well above 15°C, there would appear to be no ecologic obligation to leave that area. The best-known West Atlantic populations—those of Ascension Island, Surinam, Aves Island, and Tortuguero—all nest where no

adequate food supply is available. It is this separation that instigates seasonal migration in those colonies. If the ecology of the lost green turtle colonies of Cuba, Bermuda and Dry Tortugas, or the tiny rookeries of Yucatan or Florida, could be known, other departures from diagrammatic orthodoxy might be revealed.

One aspect of sea turtle migration has important bearing on the problem of calculating population levels. To make valid judgments of the survival outlook of a species, and to devise programs of conservation, the sizes of breeding populations must be known, at least approximately. As material for population estimates, landing records from commercial turtling operations are either lacking or hopelessly inadequate. Direct counts in foraging habitats are likewise not practicable. The only approach to population assessment, thus, is to count tracks, nests, or female turtles on nesting beaches. If each female of a colony nested every year such counts would obviously represent the number of breeding females in the population during that season, providing absolute site-fixity were assumed and in the case of the Tortuguero and Ascension green turtles reproductive homing is very strong.

A factor that complicates such calculations is a drastic unexplained fluctuation in nesting arrivals at most of the breeding shores where tagging is done (see Table 1). Another is that most sea turtles do not nest in successive years. The females that nest in a given season represent only a part of the total number of mature females in the colony. At Tortuguero and Ascension the predominant remigration intervals are 2, 3, and 4 years. These occur, on the average, in predictable percentages, and the same is probably true in other colonies. A simple formula based on the known proportions of these intermigratory periods will yield an approximation of the total number of mature breeding females in the population, and if the sex ratio is assumed to be 1:1, the size of the reproductive contingent of the population can easily be approximated.

A weakness in this procedure is that the calculations are based entirely on remigra-

TABLE 1. Mean percentages of turtles tagged at Tortuguero that are accounted for in later seasons.\*

Cohort years	% seen again as remigrants and recaptures	First column plus 26.4% tag loss percentage
1959-1966	24.4	30.9
1967-1973	36.5	46.1

\* In 1976 to 1979 the mean tag loss of the turtles remigrating to Tortuguero was 26.4%.

tions, and that at most rookeries a majority of the turtles tagged never return to nest in any subsequent season (see Table 2). At Tortuguero, when to the percentage that return bearing tags one adds the females that have tag scars, and all turtles recaptured at a distance from the nesting beach, fewer than half can be accounted for. A specious way to explain both this loss and the seasonal fluctuations is to assume that they move away to other shores to nest; but this is simply not the case—in the Ascension and Tortuguero situations, at least, and probably it is not a major factor anywhere. Another possibility is that obliteration of tag holes and scars, combined with the failure of turtle hunters to return tags that they recover, make up the missing fraction. While some of both no doubt occur, they seem unlikely to account for the whole problem. It is also conceivable that after the first nesting there is heavy mortality by predation or by disease. Balazs (1980) presents evidence that in the Hawaiian Archipelago large turtles are taken by tiger sharks more often than has been supposed. Much more evidence is needed, however, before either disease or predation should be appealed to as a principal factor in the failure of turtles to return for a second season.

If the failure of turtles to return after one visit to the nesting beach could be wholly attributed to such factors as the above, the counts of females nesting each season would be a fairly accurate index. They would not be total counts, but they would be valid samples and the equation of Carr *et al.* (1978) would yield useful values. Seasonal fluctuation would still be worrisome, but taking five year averages would reduce that error.

TABLE 2. Yearly changes in composition and size of the Tortuguero green turtle population.

Year	Recorded on miles 0-4		Remigrants and recruits	Number of encounters recorded	Total no. of turtles nesting miles 0-21
	Remigrants	Recruits			
1971	150	725	875	1,283	8,446
1972	183	1,416	1,599	2,553	15,426
1973	133	836	969	1,523	9,351
1974	103	489	593	791	5,723
1975	147	514	661	1,064	6,378
1976	462	1,936	2,398	3,567	23,142
1977	101	328	429	696	5,105
1978	530	2,268	2,798	4,592	27,041
1979	104	324	428	738	4,128

However, there is another possibility that seriously confuses the situation. This is the fact that the missing majority may include a component of turtles that nest once and then move off into demographic limbo, perhaps living on indefinitely, but never breeding again anywhere (Hughes, 1980). This again is conceivable although biologically it is an unattractive theory. Recent evidence suggests that green turtles may take as long as 30 to 40 years to reach sexual maturity. For a species with such a protracted period of development to derive from one group of females only a single season's reproduction, while another group returns repeatedly through long life spans, seems a bizarrely non-adaptive trait. It has been proposed that the so-called yellow turtle of the Galapagos Islands may be an endocrinologically aberrant, non-reproducing form of the local breeding population of *C. mydas agassizi* (Pritchard, 1971a). Certainly, larger green turtles have been caught in the sea than are recorded on nesting beaches. Moreover, on the Great Barrier Reef, Colin Limpus (personal communication) has had under observation a loggerhead that nested once and was later seen over a period of eight years but never reappeared on its nesting beach. Despite all these suggestive possibilities, however, there is no complete explanation of the loss of the "missing majority" of the sea turtles that appear to make only one migration to the nesting beaches of the world.

Thus, some of the missing group nest

one time and then die of disease or are lost to predators or exploitation. Other one-time migrants may yield to premature sexual senility, or other endocrinologic trouble. In all these cases, the loss affects the remigration-interval formula of Carr *et al.* (1978) for converting nesting females to instantaneous breeding population. Meylan (1980*b*) points out that only the predictably remigratory percentage of the season's arrivals should be used in the equation; and that the number of predictably one-time migrants for that season should merely be added to the calculated total.

Whatever the reason or reasons for the prevalence of one-season nesting may be, the uncertainties involved weaken the only procedure we have for determining sizes of populations, and it is incumbent on any tagging program that expects to generate data for this vital procedure to determine as carefully as possible the degree to which tag loss, and the failure of people to send in recovered tags, are factors in building up the "lost majority."

When to the difficulty of integrating the stations and schedules of reproductive migration is added the problem of tracing the paths and stopping places of other ecologic travel, a complete understanding of the life cycle of a sea turtle of any kind seems unachievable. Tag recovery away from nesting beaches varies markedly from one program to another. When a species is usually taken only accidentally, or incidentally in trawls, as the leatherback and loggerhead are, it is easy to see why post-nesting returns should be meagre. As populations diminish and commercial turtling decreases, long distance recoveries will become even more infrequent, and some fundamental questions will remain unanswered. For example, since Bleakney (1955) and Moulton (1963) planted the idea that *Dermochelys* is a regular visitant in northern coastal waters, evidence of the prevalence and northward extent of this migration has grown rapidly. It now seems probable that the leatherbacks that assemble to nest in the Guianas go regularly north in the Gulf Stream System and forage on jelly fish off Nova Scotia and New-

foundland. Because of low tag returns this fascinating possibility must rest on largely circumstantial evidence. Of 1,835 leatherbacks tagged in Surinam, only 6 have been recovered (Pritchard, 1971*b*, 1976). Of more than 10,000 tags put on leatherbacks in French Guiana during the last three years, only one long-range recovery has been made (J. Fretey, personal communication to A. Meylan).

More tag-recovery data are available for *Chelonia mydas* than for any other species, but even this life cycle is only sketchily known. An important obstacle is the "lost-year" gap, and the attendant difficulty of visualizing where, at its end, the young shift from pelagic sea-surface life into the benthic littoral habitats in which older juveniles are regularly found. Another block is an almost complete lack of understanding of what I have called—and been called down for calling (Balazs, personal communication)—developmental migration. One objection to the phrase is that it distorts the ornithologic sense of the term "migration," because the developing animals do not commute, but instead progress from station to station as they change in size and in ecologic requirements. The other trouble is that green turtles of different age groups may sometimes occur in the same area. This appears to occur wherever available forage resources will support both the mainly carnivorous juveniles and the plant eating adults. Two such localities are the Gulf Coast of Central Florida, and Florida Bay, where, before the depletion they suffered during the past 40 years, both mature and juvenile green turtles could be taken in the same net. By 1955, when Carr and Caldwell began a tagging project at Cedar Key, no mature turtles were ever netted on the inshore flats. Young ones from 4 to 50 kg in weight were relatively abundant there, however, and it was the periodicity in the movements of these—their appearance in April and disappearance in November, as well as a tendency for turtles to be consistently larger offshore than in the inshore flats—that suggested the term "developmental migration." At Cedar Key turtles clearly immigrated in April, and then moved

away to some other locality in November. There is a similarly itinerant colony at Bermuda (Frick *et al.*, 1980) and the regular occurrence of young sea turtles on certain West Indian and tropical Pacific islands where nesting is unknown seems clear evidence that developmental travel takes place there, as the turtles progress toward maturity.

Related to the problems of tracing developmental migrations is our inability to say whether, under a non-annual breeding regimen, all the off-season female turtles remain on the feeding grounds during the nesting season, or whether some make the migration to the nesting shore without breeding. Another question is whether all mature males go to the nesting shore, or whether some of them, too, are governed by non-annual sexual periodicities. Still another related uncertainty is whether sub-mature females make an initial migration to the breeding ground without nesting. Such gaps in knowledge of even the best known populations of sea turtles show the urgent need to reinforce the data from tagging at nesting beaches by tagging in foraging and developmental habitat.

There thus appears to be some utility in the concept of a developmental habitat; and this is reinforced by evidence from the "lost year" of hatchling ecology. The swim-frenzy subsides after a few hours or days, and the turtles must then become planktonic, passing the period either constantly drifting in weed rafts, or in some exceptionally rich field of macro-plankton forage. Their initial incessant swimming urge and strong open-sea orientation seem clearly designed to take them into long-shore currents (Frick, 1976; Carr and Meylan, 1980). In any case most hatchlings quite clearly make protracted passive migrations, and during the one or more years of their absence they either drift far away in major currents, or circle repeatedly in local eddies. The first year is, thus, itself a passive change of developmental station; and when this ends, the moving of the yearlings into littoral habitats is yet another—and so on.

The special case of the West Caribbean population of *Chelonia*, which nests in Cos-

ta Rica, invites further speculation, because of the relation of its nesting shore to the Southwest Caribbean Gyre. Carr and Meylan (1980) called attention to the suggestive proximity of the gyre to the Tortuguero nesting shore, and pointed out that the whole life cycle of the population might be completed in the southwestern Caribbean. As substantiation they recorded finding hatchlings a hundred miles downstream from Tortuguero in that current, and suggested that Tortuguero juveniles might pass the "lost" interlude circulating with the eddy—instead of being carried away to unpredictably distant places by the North Equatorial Current and Gulf Stream System. Sargassum rafts are numerous in the gyre, and invertebrate food is plentiful in these. There thus is no reason to doubt that the early juvenile stages could be completed there.

The northwestern arc of the eddy washes the edges of Miskito Bank in Nicaragua, the main home foraging ground of the population. The southern edge moves past the coasts of Panama and Colombia, from which another segment of the nesting colony goes to Costa Rica to breed. In both regions, besides the turtle grass beds on which the adults feed, there are extensive appropriate developmental habitats in which young green turtles regularly occur. It is therefore possible that both the northern and southern contingents of the Tortuguero breeding population pass their entire life cycles within the Southwest Caribbean Gyre and the region around its perimeter.

None of the life cycles of the seven species of sea turtle is well understood. Of the lot, that of Kemp's ridley once seemed the most susceptible to elucidation, because only a single breeding population was involved. There is no way of knowing whether other nesting colonies may formerly have existed. The general dearth of nesting by any sea turtles anywhere around the Gulf of Mexico is hard to account for. There are extensive good sea beaches there. Ogren (1978) suggested that propitious current relations might explain the existence of the Rancho Nuevo *arribadas*, although the complexity of cur-

rents in the Gulf makes it impossible to identify the advantages that might be involved. It may be a straw in the wind that there is a seasonally strong onshore movement of currents along the Texas coast during hatching time (Temple and Martin, 1979). This might account for the lack of *arribadas* there (Ogren, 1978) and also for the scant nesting of loggerheads on the same coast (Hildebrand, 1980).

At the time the breeding ground of *L. kempi* was discovered in 1962, attention to the species had centered mainly on its Floridian and Atlantic contingents, and on a down-stream size-gradient shown by specimens available in museum collections. Now, there have been enough tag recoveries to identify two main forage grounds to which the mature turtles repair after nesting at Rancho Nuevo, one in Campeche, the other off western Louisiana (Chavez, 1968; Pritchard and Marquez, 1973). Hildebrand (1980), on the basis of data from tagging, trawler catch and his own extensive observation, has suggested that the whole life cycle may be consummated within the Gulf of Mexico, and this seems a definite possibility. It appears probable that the entire population is not so contained, however. The abundance and predictable size classes of young ridleys on both coasts of Florida and northward on the Atlantic Coast make it seem unlikely that all Atlantic ridleys are lost to the population. Before the ridley holocaust of the 1950s, juveniles—usually subadults—were numerous along the coasts of Florida and in Florida Bay. On the central Gulf coast they were seasonally abundant, regularly turning up each spring in shallow coastal waters, where they were frequently taken in nets set for green turtles (Carr and Caldwell, 1956). The older literature on *L. kempi* reveals no other locality in which immature ridleys were originally as abundant as they were in peninsular Florida, although Coker (1906) considered the species to be common in North Carolina.

An anomaly in the pattern is that another locality in which ridleys occur frequently is the coast of New England, and that on the average, these are smaller than

those known for any section of the U.S. or Mexican coast, with the possible exception of Alabama (Larry Ogren, personal communication). In the 1930s herpetologists began to realize that most of the small New England sea turtles labeled *Caretta* in museum collections were actually ridleys (Barbour, 1942; Carr, 1942; Dodge, 1944). Later on a large "fleet" of very young ridleys stunned by cold in Vineyard Sound was reported by Dr. William E. Schevill of Woods Hole (Carr, 1957). Numerous more recent records suggest that New England might be a regular station in the developmental ecology of a part of the species (Lazell, 1979). If so, the young turtles there must have either emerged from the current farther south and swum north, or have been transported into coastal waters by local eddies of the Gulf Stream off New England.

Recent evidence indicates that meanders of the Gulf Stream deepen markedly in this area and that it generates eddies that often move up to and across the edge of the shelf (Ingham, 1979). How often, and how far, they move across the shelf itself is not clear, but the conclusion that these detached bodies of warm water give northern waters their ridleys seems inescapable. According to Ingham (1979), in 1977 an exceptional number of "warm-core Gulf Stream eddies," 70–270 km in diameter, passed through the slope water along the edge of the continental shelf in the region of Georges Bank and the Mid-Atlantic Bight. He cited reports that nine other warm-core eddies formed that year, eight in the first four months, one in July. Besides these, three more that had formed in 1976 were still intact in the area. Throughout the year there were at least two eddies adjacent to the shelf edge between Virginia and Georges Bank, and in May there were five. The life spans of these ranged from 37 to more than 300 days, with an average of 150 days. Cummings *et al.* (1979) described meander development and the formation of "rings" in the same region in June–July, 1979, using the term ring for an eddy formed by detachment of meanders, as contrasted with those otherwise generated. Their temperature mea-

surements were made from an aircraft using AXTB. Figure 1, (after Gulfstream), shows a particularly active system of meanders and associated eddies in August 1977.

I can find no evidence in the literature that the eddies ever cross the shelf, so the problem of getting the little turtles into littoral habitats remains. According to Ingham (1979) the 1977 eddies damaged the gear of lobster and crab fisheries, but this apparently occurred only on the slope and outer shelf, too far out to bring planktonic drifters into shallow water. Ekman transport moves surface water toward land, off both New England and the Mid-Atlantic Bight. Ingham (1979) suggested that in 1977 this Ekman drift moved menhaden larvae within range of the estuaries of North Carolina. It could be this effect that carries juvenile turtles to shore. In fact, no other possibility occurs to me.

Thus, the picture that fuzzily emerges includes a single nesting place in Tamaulipas, adult feeding grounds in Louisiana and in the Campeche-Tabasco area; a seasonal way-station for young and subadults in Florida; somewhat smaller size groups distributed northward into New England waters; and occasional, even smaller individuals, in East Atlantic waters.

What the smaller sizes of the more northerly distributed ridleys evidently mean is that from the time their swim-frenzy abates, until their lost year ends, little ridleys, like other hatchling sea turtles, are planktonic and at the mercy of whatever current system flows by the nesting beach. The currents of the western Gulf of Mexico are not very well known, but during the hatching season at Rancho Nuevo, mid-June to mid-August, a hatchling swimming offshore could initially be carried either northward or southward (Temple and Martin, 1979). In either case, however, it would sooner or later be picked up by the north-trending Loop Current. This could carry it into the three-knot Florida Current, through the Florida Straits, and northward along the Atlantic Coast in the Gulf Stream. Although Florida is bypassed, the young ridleys somehow cross the shelf into littoral habitat in the Mid-Atlantic Bight and Gulf of Maine.

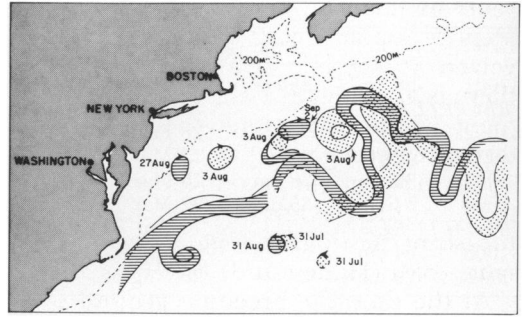


FIG. 1. Positions of the Gulf Stream and eddies at beginning (dot pattern) and end (line pattern) of August 1979, as determined by satellite infrared imagery. The southwestward shift of the eddies was caused by Ekman transport (after Gulfstream, August 1979, p. 2).

A complication of the foregoing rationale is that the growth rates of the turtles *vis-à-vis* the speed of the currents that carry hatchlings away, and later deposit yearling turtles, have not been considered. The smallest New England and East Atlantic specimens have been "lost" at sea for periods much longer than necessary to complete direct journeys from the breeding shore to the point of their downstream emergence. This is true even in the cases of the longest post-natal travel. According to my rough calculations, if a Rancho Nuevo hatchling took the main downstream route—the Loop Current and the Florida Current—without detouring in local gyres, it should arrive off Boston in about 100 days. Under the culture regimen used in the Kemp's Ridley Project at the NMFS laboratory at Galveston, the young ridleys reach weights of 0.7–1.2 kg in about 9 mo (Klima and McVey, 1980). The New England ridleys are consistently larger than this. And of 72 ridleys measured by Carr and Caldwell (1956) in the Cedar Key-Crystal River area of Florida, the smallest was 25.5 cm and the rest ranged in length between 38 cm and 64 cm. All of these had obviously lived longer than the direct travel time for a plankton in the main currents. The necessary inference is that they had either passed some months in some other coastal habitat or had been side-tracked in eddies.



TABLE 3. Data on juvenile ridleys tagged in Alabama, the first five by Gary Gaston, the last by Larry Ogren.

Tag #	CL	CW	Date	Location
G1001	28 cm	25 cm	10 Feb 75	0.5 mi. south of Dauphin Is.
RECAPTURED:			10 Apr 75	Same area, by shrimper
G1002	34 cm	35 cm	28 Feb 75	West end Dauphin Is., 25 ft. deep
RECAPTURED:			12 May 75	Long Beach, Mississippi
G1003	39 cm	38 cm	10 Mar 75	Mobile Ship Channel, 25 ft. deep
G1004	34 cm	35 cm	22 Mar 75	1 mi. south of Dauphin Is.
RECAPTURED:			12 Jun 75	Bayou Terre Aux Bouef, St. Bernard Parish, Louisiana
G1006	64 cm	66 cm	16 Sep 75	North of Dauphin Is., 12 ft. deep
F0002	29 cm	26 cm	26 Aug 66	Big Gulley, East of Mobile Pt., 4 fathoms

The New England size group has reached a stage at which ridleys begin to forage on the bottom, and their ecology is probably similar to that of the adult. When they move south their travel is no doubt oriented by the same signals and senses that take mature turtles out of any temperate zone habitat in winter time. Every year, for instance, Florida loggerheads, Gulf of California black turtles and presumably all sea turtles that seasonally enter temperate waters have either to emigrate, or go into the mud (Felger *et al.*, 1976; Carr *et al.*, 1980; Ogren and McVea, 1980). Most of them probably leave for warmer regions; and while temperature is no doubt the trigger, it is not clear how it could provide the guide signs by which the southward travel is oriented. Following a temperature gradient would seem to require incredibly keen sensory assessment of changes at successive points along trial travel paths. But my present aim is not to explain guidance mechanisms; it is only to account for the presence of ridleys in the places in which they occur. There are little ones in New England, and bigger ones in Florida, and unless the northern ones are lost to the population we have to conclude that they swim to Florida under their own motivation and efforts.

The alternative possibility, that they never go back at all, that all post-Florida ridleys may be lost waifs, is reinforced by the occurrence in European waters of juveniles even smaller than the average for the U.S. Atlantic coast. The smallest ridley ever recorded away from the nesting shore is a specimen 99.7 mm in shell length from the Azores (Deraniyagala, 1939). Most Eu-

ropean specimens range in shell length from 10 to 25 cm, and they are usually cold-stunned or dead when found. Brongersma (1980) suggests that small loggerheads that occur in the same area probably are derived from Old World nesting grounds; but *L. kempi* has none there. For reasons I gave long ago (1957) I am inclined to consider them waifs. Unless they navigate the return to American waters in very sophisticated ways, the Gulf Stream System would either take them northward past England to the arctic, or southward toward the Caribbean. In the former case they would perish; in the latter they would turn up along windward shores of the Antilles. Ridleys do turn up there, but they are *L. olivacea* from the Guianas or Africa—not *L. kempi*.

One station where young ridleys have recently been reported (Table 3, and Larry Ogren, personal communication) is the Gulf of Mexico off Alabama, particularly in an area known as Big Gulley. Besides the tag recoveries shown in the table, Ogren has had what he considers a trustworthy report from shrimp trawlers that on 21 July 1977, 4 or 5 ridleys per tow, for a total of 100 turtles, were taken by one vessel. During the period 14–18 July, weights of the "black turtles" (ridleys) taken were 2.2–2.7 kg to 36–50 kg. The occurrence of young turtles of these sizes adds some credence to the possibility that a part of the population completes its life cycle in the Gulf of Mexico.

It is hard for me to think of the Atlantic Coast ridleys as demographically dead, but evidence that the Gulf is the entire range of a part of the population is growing. The

parallel with the postulated dual cycle of the Tortuguero green turtle is striking—with some hatchlings maturing locally, and others passively emigrating. For me, this adds mystery to the ridley cycle. The Gulf of Mexico is small, and very heavily fished, by all kinds of fishermen, gathering all kinds of creatures. Why do these people fail to find other developmental habitats of ridleys the size of those the Big Gulley trawler took? And where, one wonders, were the Big Gulley juveniles during the time it took them to grow to the sizes of those the trawler caught?

I set out to review the ridley life cycle because it seemed to be less complex than those of other species. So long as expatriation of hatchlings by the Gulf Stream was postulated, we could blithely imagine the lost young out there in the ocean somewhere, maybe in the Sargasso Sea. If instead they are shut up with their parents in the Gulf of Mexico the life cycle of the ridley becomes the most mystifying of all, and the lost year puzzle is confirmed as the most substantial of all obstacles to understanding the ecology of sea turtles.

#### ACKNOWLEDGMENTS

The background research for this paper was supported by the National Science Foundation and the Caribbean Conservation Corporation.

#### REFERENCES

- Balazs, G. H. 1979a. Synopsis of biological data on the green turtle in the Hawaiian Islands. National Oceanic and Atmospheric Admin., Nat'l. Marine Fisheries Serv., contract 79-ABA-02422, Sept., 180 pp.
- Balazs, G. H. 1979b. Loggerhead turtle recovered from a tiger shark at Kure Atoll. 'Elepaio 39(12):145-147.
- Barbour, T. 1942. New records for ridleys. Copeia 1942:257.
- Bleakney, S. 1955. Four records of the Atlantic ridley turtle, *Lepidochelys kempi* from Nova Scotia. Copeia 1955:137.
- Brongersma, L. D. 1980. Marine turtles of the eastern Atlantic Ocean. Proc. World Conf. on Sea Turtle Conservation, 26-30 November 1979, Washington, D.C. (In press)
- Carr, A. 1942. Notes on sea turtles. Proc. New England Zool. Club Vol. 21, 16 pp.
- Carr, A. 1957. Notes on the zoogeography of the Atlantic sea turtles of the genus *Lepidochelys*. Rev. Biol. Trop. 5(1):45-61.
- Carr, A. F. and D. K. Caldwell. 1956. The ecology and migrations of sea turtles, 1. Results of field work in Florida, 1955. Am. Mus. Novitates 1793, 23 pp.
- Carr, A. F., M. H. Carr, and A. B. Meylan. 1978. The ecology and migrations of sea turtles, 7. The West Caribbean green turtle colony. Bull. Amer. Mus. Nat. Hist. Vol. 162: Article 1, 46 pp.
- Carr, A. F. and A. B. Meylan. 1980. Evidence of passive migration of green turtle hatchlings in sargassum. Copeia 1980:366-368.
- Carr, A. F., L. Ogren, and C. McVea. 1980. Apparent hibernation by the Atlantic loggerhead turtle off Cape Canaveral, Florida. Biol. Conserv. (In press)
- Chavez, H. 1968. Marcado y recaptura de individuos de tortuga lora *Lepidochelys kempi* (Garman). Inst. Nac. Inv. Biol. Pes., Mexico, Vol. 19, 28 pp.
- Coker, R. E. 1906. The cultivation of the diamond-back terrapin. North Carolina Geol. Surv. Bull. 14:1-69.
- Cummings, B. B., G. A. Botthardt, and R. L. Barrett. 1979. Aircraft observations of Gulf Stream meander development and ring formation. Gulfstream 5(8):2-7.
- Dampier, Captain Wilham. 1906. Dampier's voyages [1679-1701]. John Mansfield (ed.) New York. 2 vols.
- Deraniyagala, P. E. P. 1939. The Mexican loggerhead in Europe. Nature 144:156.
- Dodge, E. S. 1944. Status of the ridley turtle in Massachusetts waters. Copeia 1944:120-121.
- Felger, R. S., K. Clifton, and P. J. Regal. 1976. Winter dormancy in sea turtles: Independent discovery and exploitation in the Gulf of California by two local cultures. Science 191:283-285.
- Frick, J. 1976. Orientation and behavior of hatchling green turtles (*Chelonia mydas*) in the sea. Anim. Behav. 24:849-857.
- Frick, J., D. B. Wingate, and J. Burnett-Herkes. 1980. An attempt to re-establish a green turtle nesting rookery on Bermuda. Proc. World Conf. on Sea Turtle Conservation, 26-30 November 1979, Washington, D.C. (In press)
- Green, D. 1979. Double tagging of green turtles in the Galapagos Islands. Marine Turtle Newsletter 13:4-9.
- Hildebrand, H. 1980. A historical review of the status of sea turtle populations in the western Gulf of Mexico. Proc. World Conf. on Sea Turtle Conservation, 26-30 November 1979, Washington, D.C. (In press)
- Hughes, G. H. 1980. Nesting cycles in sea turtles—typical or atypical. Proc. World Conf. on Sea Turtle Conservation, 26-30 November 1979, Washington, D.C. (In press)
- Ingham, Merton C. 1979. Marine environmental conditions off the Atlantic and Gulf Coasts of the United States, January 1977-March 1978. Marine Fisheries Rev. May-June, 35-47.
- Klima, E. F. and J. P. McVey. 1980. Potential and problems of headstarting Kemp's ridley turtle.

- Proc. World Conf. on Sea Turtle Conservation, 26–30 November 1979, Washington, D.C. (In press)
- Lazell, J. D. 1979. Boreal and temperate migratory regimes of Atlantic marine turtles. *Amer. Zool.* 19:954. (Abstr.).
- Limpus, C. J. 1980. The green turtle *Chelonia mydas* (L.) in eastern Australia. Proc. Seminar on Management of Green Turtles in Eastern Australia, James Cook Univ. of N. Queensland, Townsville, June 28, 1979. (In press)
- Meylan, A. B. 1980a. Sea turtle migration—evidence from tag returns. Proc. World Conf. on Sea Turtle Conservation, 26–30 November 1979, Washington, D.C. (In press)
- Meylan, A. B. 1980b. Estimation of population size in sea turtles. Proc. World Conf. on Sea Turtle Conservation, 26–30 November 1979, Washington, D.C. (In press)
- Moulton, J. M. 1963. The recapture of a marked leatherback turtle in Casco Bay, Maine. *Copeia* 1963:434–435.
- Ogren, L. 1978. Survey and reconnaissance of sea turtles in the northern Gulf of Mexico. Report to National Marine Fisheries Service.
- Ogren, L. and C. McVea. 1980. Apparent hibernation by sea turtles. Proc. World Conf. on Sea Turtle Conservation, 26–30 November 1979, Washington, D.C. (In press)
- Pritchard, P. C. H. 1971a. Galapagos sea turtles—preliminary findings. *J. Herpetology* 5(1–2):1–9.
- Pritchard, P. C. H. 1971b. The leatherback or leathery turtle *Dermodochelys coriacea*. IUCN Monograph 1:1–39.
- Pritchard, P. C. H. 1976. Post-nesting movements of marine turtles (*Cheloniidae* and *Dermodochelyidae*) tagged in the Guianas. *Copeia* 1976:749–754.
- Pritchard, P. C. H. and R. Marquez. 1973. Kemp's ridley turtle or Atlantic ridley, *Lepidochelys kempi*. IUCN Monograph 2. Marine Turtle Series. Morges, Switzerland.
- Temple, Robert F. and John A. Martin. 1979. Surface circulation in the northwestern Gulf of Mexico as deduced from drift bottles. National Oceanic and Atmospheric Admin. Technical Rept. NMFS SSRF-730.