

## Delayed Feeding in Neonatal Kemp's Ridley, *Lepidochelys kempii*: A Captive Sea Turtle Management Technique

CLARK T. FONTAINE<sup>1</sup> AND THEODORE D. WILLIAMS<sup>1</sup>

<sup>1</sup>U.S. Department of Commerce, National Oceanic and  
 Atmospheric Administration, National Marine Fisheries Service,  
 Southeast Fisheries Science Center, Galveston Laboratory,  
 4700 Avenue U, Galveston, Texas 77551 USA  
 [Fax: 409-766-3508]

The National Marine Fisheries Service (NMFS), Galveston Laboratory, Galveston, Texas, has been involved in the husbandry of captive sea turtles since 1978 (Klima and McVey, 1982). The majority of the sea turtles reared from neonates at the NMFS Galveston Laboratory have been Kemp's ridley, *Lepidochelys kempii*, which were part of an international effort to restore this endangered species to its original population status (Klima and McVey, 1982; Mrosovsky, 1983; Caillouet, 1984; Fontaine et al., 1985, 1989, 1990). This aspect of the recovery effort, referred to as the Head Start Experiment, was terminated at the end of the 1992 year-class rearing season upon recommendation by a special review panel (Eckert et al., 1992). Secondly to the Kemp's ridley, large numbers of loggerhead sea turtle, *Caretta caretta*, intended to be used in turtle excluder device (TED) certification trials (Watson et al. 1986; Mitchell et al., 1989), have also been reared from neonates in the facility.

The ridley and loggerhead sea turtle possess a large internal yolk-sac that physically blocks or "squeezes off" the digestive tract including the entire stomach and intestines in neonates of < 5 days of age. Thus, feeding the neonates at too early an age results in a mechanical digestive problem. The turtle is unable to pass the ingested food due to the physical blockage of the digestive tract by the large yolk-sac and the food becomes compacted in the lower portion of the esophagus. With time, this compaction becomes anaerobic which in most cases leads to the death of the animal (SHD or sudden hatchling death syndrome as described by Leong et al., 1989).

This paper describes the technique of delayed neonatal feeding in captive reared ridleys of the 1993 year-class and discusses ramifications of feeding sea turtle neonates prior to yolk-sac resorption. The intent of delaying the onset of feeding in neonates is to increase the chance of neonatal survival in captivity by reducing the physical size of the yolk-sac through yolk utilization before feeding is initiated.

**Materials and Methods.** — The rearing facilities and husbandry techniques used in rearing sea turtles at the NMFS Galveston Laboratory have been described in detail (Fontaine et al., 1985; Caillouet et al., 1986; Fontaine et al., 1989).

Because of the endangered nature of the Kemp's ridley sea turtle, U. S. Fish and Wildlife Service permits do not allow research on these turtles that even implies harm, thus it was not possible to determine volumetric yolk-sac utilization from apparently normal, healthy neonates. Every sea turtle that died at the NMFS Galveston Laboratory during this study, however, received a gross necropsy examination. From these carcasses, selected individuals were taken to the Texas Veterinary Medical Diagnostic Laboratory (TVMDL) at College Station, Texas, for clinical diagnosis when warranted. In each instance, the carcass was opened and examined closely internally for yolk-sac retention and measurement of the size of the yolk-sac in terms of percent volume of the body cavity. Since these neonates had died the data from these examinations may not reflect the normal resorption rate.

The 1993 Kemp's ridley year-class delayed feeding data are presented here as representative of this captive rearing technique. The neonates of the 1993 year-class were shipped to the NMFS Galveston Laboratory in small plastic cartons that had a layer of wet urethane foam on the bottom to keep them wet during shipment and to also serve as padding. Upon receipt a representative sub-sample of 25 neonates was taken and weighed on a Mettler balance (reading to 0.1 g). After weighing, each turtle was placed in an individual numbered carton within a holding "raceway" and then re-weighed every 24 hours. During the weighing no attempt was made to dry each turtle.

The data were summarized from the initial weighing (day 0) in 24-hr increments (days in seawater) by geometric means (Aitchison and Brown, 1976) calculated as:

$$\bar{X}' = \exp(\overline{\ln x} + s^2/2)$$

where  $\bar{X}'$  = estimated mean mass in grams,  $\overline{\ln x}$  = mean of the natural logarithm of mass, and  $s^2$  = variance of  $\overline{\ln x}$ . The geometric means were regressed on the square root of days in seawater so that

$$\ln W = a + (bT^{0.5})$$

where  $\ln W$  = mass at time T, T = raceway time in days, a = y intercept, and b = slope of regression.

The increase in mass of unfed neonates may best be described by calculating the actual mass change of each individual by day in seawater and then fitting a line to the data using linear regression:

$$WtC = a + (bT)$$

where  $WtC$  = daily mass change, T = time in the raceway, a = 1.9888, and b = -1.1620.

**Results and Discussion.** — Generally, a Kemp's ridley hatchling at 3-5 days of age has a yolk-sac that occupies 85-95 % of the body cavity (*pers. comm.*, R. M. Robinson, D.V.M., Texas Veterinary Medical Diagnostic Laboratory, College Station, TX). It would appear from our data that total

**Table 1.** Daily total mass of 25 Kemp's ridley sea turtles, *Lepidochelys kempii*, for eleven days prior to being fed. These neonates were of the 1993 year-class held in captivity at the NMFS Galveston Laboratory.

Number	0	1	2	3	4	5	6	7	8	9	10	11
1	15.9	16.2	16.8	17.1	18.1	18.7	18.4	18.8	18.9	18.7	19.2	19.5
2	16.4	17.0	17.6	17.9	18.5	18.7	19.3	20.1	20.4	20.2	20.3	20.6
3	15.3	15.7	16.4	16.0	18.0	17.4	17.5	18.0	19.0	18.3	19.0	18.9
4	15.2	15.6	17.0	16.4	16.7	17.1	17.2	17.7	17.2	17.6	17.6	17.7
5	16.6	16.7	17.2	17.4	18.2	18.2	18.6	18.7	18.7	18.9	18.6	18.8
6	15.1	15.3	15.6	16.2	17.2	17.8	17.7	18.0	18.2	18.7	18.7	18.6
7	16.2	16.5	16.6	17.0	17.6	17.8	17.9	17.9	18.1	18.1	18.4	18.4
8	17.3	17.5	17.7	18.3	18.6	19.5	19.4	19.4	19.7	20.0	20.2	20.5
9	17.0	17.2	17.3	17.8	18.4	18.8	18.6	18.7	18.7	19.2	19.3	19.7
10	18.1	18.4	18.5	18.7	19.2	19.5	19.5	19.8	19.8	20.0	19.9	20.5
11	15.3	15.5	16.1	17.2	17.3	17.6	17.2	17.6	17.6	19.0	17.6	18.4
12	17.7	17.7	18.6	19.2	19.7	20.1	20.4	22.0	21.1	21.2	22.0	21.4
13	14.0	14.2	14.8	14.7	15.3	15.8	16.0	15.9	16.5	16.5	16.3	17.0
14	12.0	12.9	13.4	13.5	14.4	14.5	14.6	15.0	15.3	15.4	15.5	15.8
15	16.0	16.3	16.3	16.6	17.2	17.9	17.6	17.8	17.8	18.2	18.7	18.1
16	16.1	16.7	17.2	17.4	17.9	18.6	18.6	18.2	18.5	18.7	20.0	19.4
17	17.4	17.9	18.2	18.3	19.6	19.6	19.2	19.8	19.8	19.8	20.1	20.3
18	18.4	18.4	18.9	19.2	19.9	20.5	20.8	21.6	21.4	21.8	22.1	21.9
19	19.4	19.4	19.7	20.1	21.4	21.6	21.4	21.6	21.7	21.6	23.0	22.1
20	18.5	18.9	19.6	19.9	21.4	21.5	21.6	22.2	21.9	22.4	22.6	22.8
21	17.0	17.3	17.8	17.8	18.4	18.7	18.5	19.3	20.0	19.6	19.6	20.0
22	15.6	17.0	16.8	17.1	17.4	17.7	18.1	18.5	18.4	18.6	19.2	19.4
23	16.1	16.4	16.9	17.1	18.6	18.9	18.8	18.6	20.0	19.2	19.4	19.5
24	18.0	18.1	18.5	18.7	20.1	20.6	20.5	20.3	20.8	20.5	21.6	21.8
25	19.5	19.8	20.4	20.5	21.3	22.3	22.2	22.6	22.5	23.0	23.1	22.7
Mean	16.6	16.9	17.4	17.6	18.4	18.8	18.8	19.1	19.3	19.4	19.7	19.8

resorption of the yolk-sac in head-started neonates takes longer than anticipated. For instance, the yolk-sac was still present in a turtle of 48 days of age and occupied approximately 10% of the body cavity.

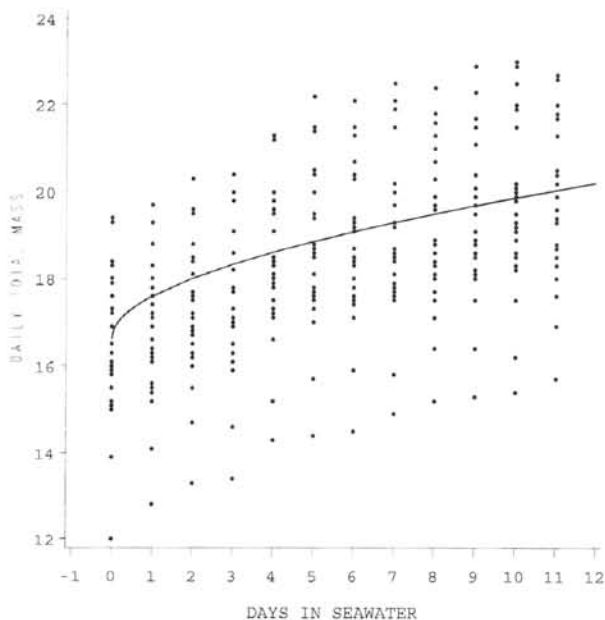
The unfed ridley neonates gained mass during the first eleven days after being placed in seawater (Table 1, Fig. 1). However, the magnitude of change in daily mass decreased with time in seawater (Fig. 2) and shortly after the eleventh

day the fitted line of daily mass change regressed on days in seawater approached zero. We believe that after the eighth day in seawater with no feeding, when the line fitted to the daily mass change approaches zero, the neonatal sea turtles may be safely fed.

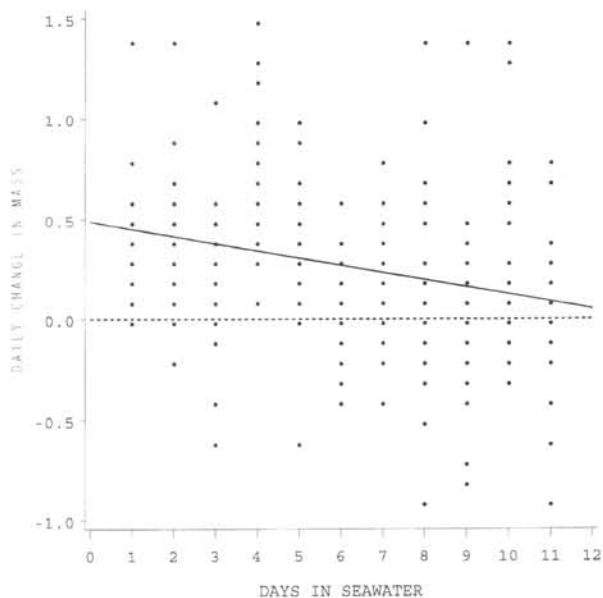
The correlations for regression of total mass on days in seawater and daily change in mass on time in seawater were low ( $r^2 = 0.213$  for total mass;  $r^2 = 0.289$  for daily mass change). The poor fits are probably due to the significant deviation in total mass and daily mass change both between individuals and within individuals.

The means of daily change in mass of neonates were fitted to a smooth curve using a cubic spline method (SAS Institute, 1988) and the geometric means of daily change in mass were regressed against the square root of time in seawater (Fig. 3). The smooth curve line fit by the spline technique probably represents the uptake and discharge of water by the neonates and the fitted regression could serve as a model to predict onset of feeding.

Kemp's ridley and loggerhead neonates, if given the opportunity, will commence active feeding even at three days post-hatching. Often this leads to compaction of the esophagus, or intestine, resulting in death of the individual (Leong et al., 1989). Therefore, neonatal Kemp's or loggerhead sea turtles being reared in captivity should be prevented from feeding until it is assured that the yolk-sac has been significantly reduced in size to prevent the problem of sudden hatchling death syndrome. It is our belief that chances for growth and survival of neonatal sea turtles during the first 90 days in captivity are greatly enhanced by delayed feeding. However, we recognize that other improvements in NMFS Galveston Laboratory husbandry techniques, such as better



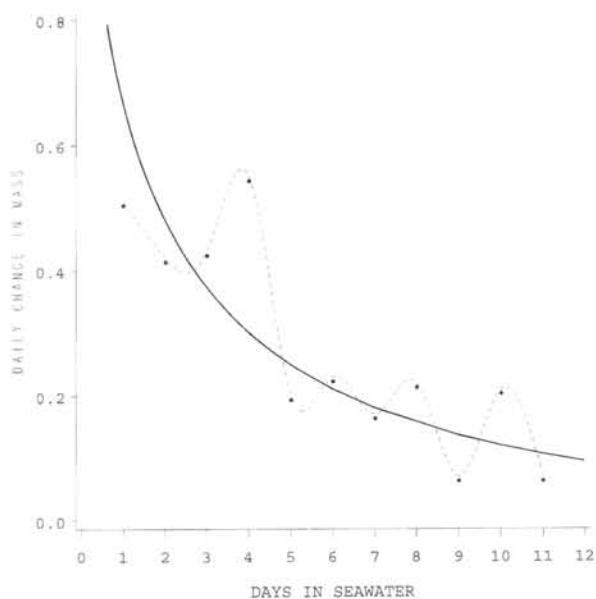
**Figure 1.** Daily total mass (g) of captive reared neonatal Kemp's ridley sea turtles ( $n = 25$ ) after being placed in seawater and prior to being fed. The fitted line is mean mass regressed on days in seawater.



**Figure 2.** Daily change in total mass (g) of neonatal Kemp's ridley sea turtles after being placed in seawater and prior to being fed (the solid line was calculated as mean daily change in total mass regressed on days in seawater).

husbandry hygiene, feeding rate control, veterinary services, water quality control, etc., contributed to the overall better survival in the later Kemp's ridley head-start year-classes. What direct impact delayed feeding had on the increased survival rate of captive reared sea turtles at the NMFS Galveston Laboratory can not be determined.

In the wild, sea turtle neonates must lose some body water to the environment during the time they spend in the sand and on the beach surface after emerging from the nest.



**Figure 3.** The mean of daily change in mass of Kemp's ridley neonates plotted against days in seawater for the 1993 year-class held at the NMFS Galveston Laboratory. The dotted line was fit to the data using the SAS spline technique and the solid line is the geometric mean of daily change in mass regressed on the square root of days in seawater (detransformed).

Any dehydration suffered at this stage can only be aggravated by osmotic water loss during the first few days of life spent at sea living on their depleting yolk-sacs (Bennett et al, 1986). It seems unlikely that animals as small as these could survive long at sea unless they are remarkably resistant to water loss, or, are capable of replenishing their body water while not feeding. Bennett et al. (1986) showed that only 31% of the mass loss in emerging turtles can be attributed directly to utilization of the yolk-sac. They also demonstrated that unfed hatchling loggerheads are capable of maintaining body mass in sea water by drinking and that the contribution of metabolic water production to their water balance is negligible. This strengthens the argument that the daily change in mass observed (Fig. 3) probably reflects active drinking of sea water and suggests that the drinking response may be triggered, or intensified, by the hydration state of the hatchling.

*Acknowledgments.* — The Kemp's ridley neonates used in these analyses were obtained from the Federal Government of Mexico, Instituto de la Pesca, and were imported into USA under CITES Permit No. 00080 issued by the U.S. Fish and Wildlife Service. The turtles were reared in Galveston under U.S. Fish and Wildlife Endangered and Threatened Species Permit No. PRT-676379 and the Texas Parks and Wildlife Department's Endangered and Threatened Species Permit No. SPR0390-038. We would like to express our appreciation to Charles W. Caillouet, Jr., Chief, Protected Species Branch, NMFS Galveston Laboratory, for his encouragement of this work. Also, we would like to recognize and thank several researchers who have worked with the husbandry of sea turtles at the NMFS Galveston Laboratory: Kathy Indelicato, Pam Howes, Sharon Manzella, Jo Anne Williams, Billy Ray Ross, John Boyd, Bob McElyea, Ben Higgins, Bradley Robertson, Dickie Revera, and Andrea Cannon. In addition, we appreciate the helpful review and comments of the manuscript by Thane Wibbels, University of Alabama-Birmingham, Birmingham, Alabama, Scott Eckert, Hubbs-Sea World Research Institute, San Diego, California, and two anonymous reviewers.

### Literature Cited

- AITCHISON, J., AND BROWN, J.A.C. 1976. The lognormal distribution with special reference to its uses in economics. Cambridge University Press, New York, 175 pp.
- BENNETT, J.M., TAPLIN, L.E., AND GRIGG, G.C. 1986. Sea water drinking as a homeostatic response to dehydration in hatchling loggerhead turtles *Caretta caretta*. *Comp. Biochem. Physiol.* 83A(3):507-513.
- CAILLOUET, C.W., JR. 1984. Essai de prevention de l'extinction de la tortue de Kemp. *Les Carnets de Zoologie* 44(2):28-34.
- CAILLOUET, C.W., JR., FONTAINE, C.T., WILLIAMS, T.D., MANZELLA, S.A., REVERA, D.B., KOI, D.B., INDELICATO, K.L.W., TYREE, M.G., LEONG, J.K., DURONSLET, M.J., AND

- MARVIN, K.T. 1986. The Kemp's ridley sea turtle head start research project: an annual report for fiscal year 1985. NOAA Technical Memorandum NMFS-SEFC-174, 37 pp.
- ECKERT, S.A., CROUSE, D., CROWDER, L.B., MACEINA, M., AND SHAH, A. 1992. Review of the Kemp's ridley sea turtle headstart experiment, 22-23 September 1992, Galveston, Texas. Report submitted to the U. S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Miami, Florida, 9 pp.
- FONTAINE, C.T., MARVIN, K.T., WILLIAMS, T.D., BROWNING, W.J., HARRIS, R.M., INDELICATO, K.L., SHATTUCK, G.A., AND SADLER, R.A. 1985. The husbandry of hatchling to yearling Kemp's ridley sea turtles (*Lepidochelys kempi*). NOAA Technical Memorandum NMFS-SEFC-158, 34 pp.
- FONTAINE, C.T., WILLIAMS, T.D., MANZELLA, S.A., AND CAILLOUET, C.W., JR. 1989. Kemp's ridley sea turtle head start operations of the NMFS SEFC Galveston Laboratory. In: Caillouet, C.W., Jr., and Landry, A.W., Jr. (Eds.). Proceedings of the First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation and Management, Texas A&M University, Sea Grant College Program, TAMU-SG-89-105, pp. 96-110.
- FONTAINE, C.T., DURONSLET, M.J., REVERA, D.B., WILLIAMS, T.D., WILLIAMS, J.A., MANZELLA, S.A., STABENAU, E.K., LANDRY, A.M., JR., AND CAILLOUET, C.E., JR. 1990. Kemp's ridley head start experiment and other sea turtle research at the Galveston Laboratory: Annual report - fiscal year 1989. NOAA Technical Memorandum NMFS-SEFC-266, 28 pp.
- KLIMA, E.F., AND McVEY, J.P. 1982. Head starting the Kemp's ridley turtle, *Lepidochelys kempi*. In: Bjorndal, K.A. (Ed.). Biology and Conservation of Sea Turtles. Proceedings of the World Conference on Sea Turtle Conservation. Smithsonian Institution Press, Washington, DC, pp. 481-487.
- LEONG, J.K., SMITH, D.L., REVERA, D.B., CLARY, J.C., III, LEWIS, D.H., SCOTT, J.L., AND DiNUZZO, A.R. 1989. Health care and diseases of captive-reared loggerhead and Kemp's ridley sea turtles. In: Caillouet, C.W., Jr., and Landry, A.M., Jr. (Eds.). Proceedings of the First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation and Management, Texas A&M University, Sea Grant College Program, TAMU-SG-89-105, pp. 177-200.
- MROSOVSKY, N. 1983. Conserving Sea Turtles. The British Herpetological Society, England, 176 pp.
- MITCHELL, J.F., WATSON, J.W., SEIDEL, W.R., AND SHAH, A.K. 1989. An alternative protocol for the qualification of new turtle excluder devices (TEDs). In: Eckert, S.A., Eckert, K.L., and Richardson, T.H. (Compilers). Proceedings of the Ninth Annual Workshop on Sea Turtle Conservation and Biology. NOAA Technical Memorandum NMFS-SEFC-232, 305 p.
- SAS INSTITUTE. 1988. SAS/GRAPH Users Guide, Release 6.03 Edition, Cary, NC.
- WATSON, J.W., MITCHELL, J.F., AND SHAH, A.K. 1986. Trawling efficiency device: a new concept for selective shrimp trawling gear. Mar. Fish. Rev. 48(1):1-9.

Received: 14 April 1996

Reviewed: 11 November 1996

Revised and Accepted: 12 September 1997

## Growth of the Turtle, *Phrynops rufipes*, in Central Amazônia, Brazil

WILLIAM E. MAGNUSSON<sup>1</sup>,  
ALDENIZA CARDOSO DE LIMA<sup>1</sup>, VALDENISE LOPES  
DA COSTA<sup>1</sup>, AND ODILON PIMENTEL DE LIMA<sup>1</sup>

<sup>1</sup>Departamento de Ecologia,  
Instituto Nacional de Pesquisas da Amazônia,  
Caixa Postal 478, Manaus, Amazonas 69011-970 Brazil  
[Fax: 55-92-642-1838; E-mail: bill@inpa.gov.br]

*Phrynops rufipes* (see color cover photo) is a medium-sized chelid turtle (carapace length to ca. 240 mm) largely restricted to closed-canopy rainforest streams in the Amazon basin where it feeds mainly on invertebrates and palm fruits (Lamar and Medem, 1982). Known localities are tightly clustered close to Manaus and in southeastern Colombia. The ecology of the species is little known and it has been described as "one of the rarest of all turtles" (Pritchard, 1984). Information on growth is important for understanding population dynamics, and turtles may have ages at maturity that vary from 5 to 25 years (Shine and Iverson, 1995). However, there is no published account of the growth ecology of *P. rufipes*.

Growth in reptiles may follow any of a wide range of the Richards family of curves which describe most sigmoidal relationships between size and age (Brisbin et al., 1984), or may follow unusual empirical patterns (e.g., Webb et al., 1983; Magnusson and Sanaiotti, 1995), and it may be difficult to distinguish statistically between candidate curves even when the true relationship is known (Abercrombie, 1992). For most species and data-collection regimes, parametric tests should not be used (Rickard et al., 1989). There may also be large interannual variations in growth, so models based on short time series may be misleading (Tucker et al., 1995). These considerations impose severe restrictions on the construction and use of representative growth curves for a species and it is necessary to evaluate individual variability when describing general growth patterns.

Variation among individuals may make it difficult to describe the mean growth pattern of a population. If variation in growth rate within individuals is as great as that among individuals, the mean age/size relationship for the population will be similar to that calculated for most individuals. In this case, growth may be adequately described by the population growth parameters. However, growth rates of individual reptiles may tend to follow parallel trajectories (e.g., Webb et al., 1983; Rickard et al., 1989; Congdon and van Loben Sels, 1993; Magnusson and Sanaiotti, 1995). When growth-rate-on-