Review of the Kemp's Ridley Sea Turtle Headstart Program

22 - 23 September 1992
Galveston, Texas

U.S. Department of Commerce
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This report represents the findings of an independent scientific review team assembled by the U.S. National Marine Fisheries Service (NMFS) whose purpose was to examine the experimental design of the Kemp's Ridley Sea Turtle Headstart Experiment. The team was charged with making recommendations to the NMFS on how to improve the project's experimental design and to propose future directions for the program. The content of this report represents the views of the independent review team and not necessarily those of the National Marine Fisheries Service.

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U.S. Department of Commerce
Ronald H. Brown, Secretary

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Historical Background

The Kemp's ridley sea turtle, Lepidochelys kempii, is classified under the Endangered Species Act (ESA) of 1973 as Endangered. This species is considered the rarest of all sea turtle species (all sea turtles occurring in U.S. waters are listed as Threatened or Endangered). Less than 50 years ago, Kemp's ridley sea turtles were considered abundant in the Gulf of Mexico. A 16 mm film record from 1947 of a single breeding aggregation (known as an Arribada) contained approximately 40,000 females at a single beach in Northeast Mexico. By 1992, the species was reduced to less than 500 nesting turtles.

In 1966, protection of the remaining turtles was undertaken by the Mexican Government at the primary nesting beach at Rancho Nuevo, Mexico, and in 1977 the U.S. Fish and Wildlife Service began a cooperative program with Mexico to support this protection. In 1978, under a complex cooperative agreement between U.S. and Mexican resource management agencies a "headstarting" program was created. Headstarting (a term first coined by Dr. Archie Carr at a meeting in Morges, Switzerland: Mrosovsky, 1983) refers to the captive hatching and rearing of young turtles to a larger size, thus passing through a vulnerable life-stage in an environment free from predators. These turtles are released to the wild where they (theoretically) have improved survival rates. Concurrent with the headstarting program, a program was created to imprint hatchlings on a beach at Padre Island National Seashore with the hope that these turtles would return to nest at Padre Island when mature. The imprinting project was discontinued in 1988, because 1) no turtles had been recorded as returning to nest and 2) it was felt that a sufficient number of turtles had been imprinted and released such that some should return over the next ten years (Shaver, 1990). To date, none of the turtles imprinted at Padre Island have returned. Subsequently, the imprinting program is focused on monitoring the (Padre Island) nesting beach.

Since 1978, the headstarting project annually imported about 2,000 Kemp's ridley eggs from the Rancho Nuevo nesting beach. An overall average of 87.1% (range 65.6% - 97.6%) were hatched, tagged and released. Tagging techniques varied among years, but turtles were either flipper-tagged with Hasco[1], model 681 metal tags, internal binary code wire tagged, microchip tagged (Passive Integrated Transponder Tag = PIT tag), or living tagged (a portion of the white plastron is surgically implanted into the dark-colored carapace). In most cases a combination of tagging methods was used. The release location for the headstarted turtles was generally offshore from the barrier islands.

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[1] Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA, or the Review Team.

The headstarting program has been controversial among sea turtle biologists almost from its inception (Allen, 1981; Buitrago, 1981; Goodwin, 1981; Mrosovsky, 1981, 1983; Mortimer, 1988; Pritchard, 1981; Woody, 1981, 1990, 1991; Taubes, 1992) because headstarting might act as a mitigation measure (Frazer, 1992). Criticism tends to revolve around concern that headstarted turtles will not nest, and that they may not integrate into wild populations due to confinement during their first year of life. Concern was also expressed that the headstart program acted to mollify resource policy makers into believing that the causes for the dramatic decline in the Kemp's ridley population do not need to be addressed

In response to these criticisms, proponents of headstarting generally stated that not enough time has elapsed for headstarted turtles to reach maturity and return to nest. They also commented that marking techniques in the early years were not adequate, and tagged turtles did not remain tagged long enough to be recognized when they are mature and are encountered on the nesting beach. Further, headstarting was an experiment, not a mitigation measure, so that it should not be considered a mitigation technique (Allen, 1990, 1992).

Experimental Design Review

The purpose of this review is to examine the experimental design of the Kemp's ridley headstarting program. We have attempted to focus on whether the design of the experiment is appropriate and provide suggestions for improvement rather than determine if the project should be continued. If and when the feasibility of headstarting is proven, its continuation will need to be judged more on an economic/policy basis. Our goal is to recommend improvements in the experimental design which will provide the scientific information needed for such a decision. As with any experiment, there are a number of elements that must be considered. The elements we chose to examine are: 1) is there a testable hypothesis? 2) are sample sizes adequate and unbiased? 3) does the experiment have a control and an experimental group? 4) does the project have an 'end point' or a final goal.

Experimental Hypothesis

The first component to be considered is the project's hypothesis. Our impression from the materials provided is that at inception, the project really didn't have an experimental hypothesis that could prove whether headstarting was an effective method to support the wild population. The program was so focused on the challenges of captive rearing that any consideration of an experimental design was overlooked. There appeared to be an assumption that survival in the marine environment was assured after hatchlings were raised for a year. However, in the last few years, in part because the program has become very successful at captive rearing of Kemp's ridleys, and because of outside pressure, an experimental hypothesis or set of goals began to emerge. In particular, a 1989 blue-ribbon review panel suggested the project consider two criteria for success (labelled as the "Provisional Criteria" and the "Ultimate Criterion") (Wibbels et al., 1989):

Provisional Criteria

A) Apparent competence of headstarted turtles at and after release (i.e., Do headstarted turtles survive and grow in the wild, and are they comparable to wild Ridleys in body weight, feeding behavior, orientation, and reactions?).

B) Ratio of recoveries (tag returns and strandings) of headstarted turtles to naturally occurring Kemp's Ridleys, taking into consideration the number of hatchlings produced at Rancho Nuevo and the number of headstarted hatchlings (taking into account the possibility of biased sampling due to the presence of tags on headstarted turtles).

C) Comparison of recovery locations of headstarted and non-headstarted ridleys.

Ultimate Criterion

A) If headstarting is successful, the proportion of nesting headstarted females should increase relative to the proportion of non-headstarted nesting females. We consider that a gradual increase in this proportion over a five-year period would be an indicator that headstarting is an effective conservation technique.

We generally agree with the "Provisional Criteria", and applaud the choice of these factors in guiding the headstart program. However, the "Ultimate Criterion" appears to be based upon the tacit assumption that the population is in a continuous state of decrease, which may have been true in 1989, but may not always be true. Indeed, data since 1987 suggest that a slight increase in the population size may be occurring (R. Byles[2]) If the wild turtle population increases, and the number of headstart turtles released remains constant, as it has for the last 12 years, the proportion of headstarted turtles in the population will decline. Thus, it will be impossible to judge whether headstarting is successful using the "Ultimate Criterion".

We suggest a more general project goal expressed as a two-part hypothesis (if the project is an "experiment" then it should logically have a testable hypothesis):

A. Headstarting can produce Kemp's ridley juvenile sea turtles which are able to join the natural, wild populations, find their way to nesting beaches, procreate and hatch viable offspring of their own.

B. Headstarted turtles demonstrate equivalent or superior biological fitness (defined as equal or better survival rates from egg to reproductive adult, and equivalent or better fecundity) when compared to wild Kemp's Ridleys.

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[2] R. Byles. U.S. Fish and Wildlife Service. Personal Commun., 1992.

Part A of the hypothesis addresses the viability of headstarting to produce productive turtles; part B of the hypothesis determines whether headstarting turtles is more effective than allowing the wild population to recover on its own once the factors which caused the population decline are removed.

Sample Sizes

The most important factor which must be considered about sample size is whether effects of the experiment can be detected when compared to a control group. In the case of this experiment, the questions are, "can it be determined that headstarted turtles survive to maturity, nest and hatch viable young?" and "if viable how does their survival and fecundity compare to wild raised turtles?". The experimental group consists of the headstarted turtles and the control group consists of wild turtles. Answering these questions requires that headstarted and marked wild turtles be detected and distinguished from each other on the nesting beach.

To detect marked (headstarted or wild-raised) turtles at the nesting beach requires a particular level of nesting beach coverage, and on the number of marked turtles available to be detected. Consequently, experimental and control group sample sizes are very important. A small number of tagged individuals will require a higher detection effort to observe any experimental effect. In this case, detection effort is positively associated with beach coverage. However, an advantage of small sample size is that fewer turtles are impacted by the experimental technique (headstarting). Conversely, large sample sizes require less detection effort to observe experimental effect. To date, the headstarting experiment annually releases a relatively small numbers of headstarted turtles. Thus, a high level of coverage on the beach is required to detect headstarted turtles. Unfortunately, this has not been the case. According to Pritchard (1990), only 50% of the nestings at Rancho Nuevo were observed during the 1989 nesting season, and such coverage was typical. The probability of detecting a headstarted turtle with a coverage of 50% is very low because headstarted turtles represent such a small proportion of the population. Furthermore, tagging techniques previously used by the headstart program virtually guarantee that the headstarted turtles will not be detected. Almost all headstart turtles have only been marked with a single flipper tag, a living tag or one of two styles of internal tags. Flipper tags, which are most readily identifiable, have a notoriously short life span (2-4 yr). Living tags have a completely unknown detection rate and may be easily misidentified. Internal tags, which are at least archival, require special detection equipment which the beach project does not have in adequate quantity.

The "blue ribbon panel" (Wibbels et al., 1989) suggested that the shrimp fleet was severely reducing the survival rate of the headstarted Kemp's population, and this possibly accounts for the complete absence of headstarted turtles at the nesting beach. They subsequently suggested that the project continue to release approximately 2,000 headstarted turtles per year for 10 years after Turtle Excluder Devices (TED) are implemented on 100% of all shrimp fishing vessels. We agree that mortality rates associated with trawling are likely high, and that TEDs should be required on all shrimping vessels, but coverage of the nesting beach was probably not adequate to detect any headstarted turtles even if the mortality due to shrimping was nil. Thus evaluation of the current headstart program will be ineffectual given the current beach coverage.

We propose that coverage at Rancho Nuevo be increased to observe all turtles that nest. All field teams should be outfitted to detect headstarted turtles. We suggest that because approximately 12,000 headstarted turtles have been released with coded wire tags and another 4,500 with PIT tags (with about another 2,000 headstart turtles due to be released within 1 year), an increase in beach coverage should be able to determine if any of those turtles are currently nesting.

We are not comfortable with relying on living tags as a means to detect headstarted turtles. Living tags are too easily misinterpreted, and there has not been adequate research to determine the retention and detection rate of those tags after release.

Experimental and Control Groups

The experimental group in this project is the headstarted turtle cohort. Approximately 2,000 of these turtles were released annually for 12 years. Marking was probably adequate to detect 16,500 of these turtles, given the proper detection equipment. The control group of the project consists of wild-raised turtles. This latter group has been overlooked, leaving no comparison by which to measure the experiment. Recent efforts using stranding data have described the distribution of the species in the Gulf of Mexico, however we believe that stranding data have many biases (e.g. only turtles which have died near the coast wash ashore, tagged turtles are more readily reported, etc.) which limit the usefulness of such data. Therefore, we recommend a rigorous mark and recapture program be undertaken. Not only will such a program allow the archival tagging of wild Kemp's ridleys and maintenance of previously attached or implanted tags, but it will allow determination of growth rates, survival rates, tag retention rates, and a host of important life history characteristics on both wild and headstarted turtles.

It should be noted that in the last few years there has been a required increase in TED use such that mortality factors on the turtle population have probably changed. Therefore, to calculate the comparative survival rates of headstarted and wild turtles, it will be necessary to capture both wild and headstarted turtles as part of the mark and recapture program. Calculation of survival rates to maturity can only be based upon those turtles captured during this program. Using the number of headstarted turtles released (with archival tags approx. 16,500) and the number later seen on the nesting beach to calculate survival rate, will give a rate biased by the high mortality associated with non-TED shrimp fishing.

Since a large number of headstarted turtles were already released with archival quality tags, we do not feel it necessary to continue to release headstarted turtles. Efforts should be concentrated on detection of previously released headstarted turtles, and the establishment of a control group.

End Point

The experiment will be considered complete when the hypothesis is proven or disproven. We suggest that if no headstarted turtles are detected nesting at Rancho Nuevo from the turtles already released, given that approximately 100% of the nesters have been examined during the next 8-10 years and that wild Kemp's ridleys identified in the mark and recapture program are detected nesting, then the hypothesis is disproven. If instead, headstarted turtles are detected on the nesting beach, then fecundity and nesting success data are needed to evaluate part B of the hypothesis on page 3.

Summary

Our summary recommendations suggest some protocols that would be considered impossible for most sea turtle species. However, because of the small size of the Kemp's ridley population, which nests on a single primary beach, we believe these recommendations are feasible. In summary we propose the project proceed in the following manner[3]:

Survival Rate Determination

Survival rates of all size/age classes of wild and headstarted turtles should be assessed. Determining survival rates for wild and headstarted populations should be the highest priority of the headstart program for the next few years. Because the program demonstrated a capacity to raise and release turtles, and a large number of archival marked turtles are already in the population, we feel that additional headstarting is unnecessary and instead the NMFS efforts should focus on understanding how the released turtles are faring. Ultimately it will be important to gain information on the survival/fitness of headstarted turtles compared to the wild populations. We propose that the NMFS focus on a large-scale mark and recapture program designed to gather the following information (in order of priority) for both experimental (headstarted) and control (wild) turtles:

A) Survival rate of hatchlings to maturity.
B) Average survival rate of juvenile size class turtles to maturity.
C) Growth rates of juvenile turtles.
D) Behavior: habitat selection, movement, and migration patterns.
E) Physiology: compare physical fitness of headstarted turtles to wild caught turtles.
F) Sex ratios of in situ populations.
G) Size frequency distributions of juvenile populations.
H) Determine age to maturity.

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[3] It should be noted that some of these tasks may not be the direct jurisdictional responsibility of the National Marine Fisheries Service. However, the team feels strongly that NMFS should be encouraged to support activities which help determine the outcome of its experiment.

The program should establish a large number of netting/capture areas around the Gulf of Mexico and along the U.S. east coast for the purpose of capturing and archival tagging Kemp's ridleys. Data on size, sex, habitat characteristics, as well as some physiological parameters and food preferences should be gathered. Simultaneously, beach coverage should be increased to observe 100% of all nesters, and all workers should be equipped to detect archival tags.

To determine wild turtle survival rates from hatching to maturity, we recommend the following. For two consecutive seasons, a large number of wild hatchlings should be released with archival tags. The number of hatchlings to be tagged can be calculated based on the data in Appendix I. A most critical value that must be estimated for sample sizes to be valid, is survival rate to maturity. This review team is uncomfortable trying to predict that estimate, though it is probably fair to assume that it lies between .01 and .001 (from hatchling to maturity). We strongly recommend that as large a sample size as possible be marked[4] to reduce the error of the final estimate and that hatchlings be marked for two consecutive seasons to reduce stochastic year effects on survival. Each year class should be tagged such that the location of the tag will indicate year class. We realize that this is a very ambitious task, but the result will be critical to analyze part B of the hypothesis: that headstarted turtles have an equal or better survival rate to maturity than wild turtles. By conducting this tagging concurrent to the netting program, it may be feasible to recapture some of these turtles as they grow. We feel it necessary to recommend a large number of hatchlings be tagged, because of the (assumed) high mortality rate of small turtles, and because we hope that the netting program will recapture some of these, if enough have been marked. However, before starting this experiment it should be demonstrated that the use of magnetic wire-coded or PIT tags will not adversely impact hatchlings (by using techniques such as those developed by Lohmann (1991)). This is particularly true of magnetic tags since we know that sea turtle hatchlings are sensitive to magnetic fields.

Determination of the number of hatchlings that should be tagged will rely heavily on the estimated survival rate to maturity and the appropriate error rate. The error rate must be lower than the survival rate to keep the confidence interval of calculated survival rate narrow, and to exclude zero from the interval. For more on the calculation of the sample size required, see Appendix I.

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[4] We recommend that prior to initiation of these projects that the NMFS assemble a team of experts in the experimental design of mark and recapture projects. We cannot overemphasize this recommendation. We have proposed a wide range of goals for these tagging programs, each of which may require a different sample size, and will take specialized expertise to determine the sample size that will meet all of the project goals.

Tag Retention Rate

Tag Retention rates for wild and headstarted turtles at different life history stages should be assessed. The lack of data on tag retention rates is a major stumbling block of the current headstart program. Specifically, all headstarted and wild-captured turtles should be double-tagged with visible tags and at least single tagged with archival tags. Furthermore, the tagging program should be organized and well supported such that its longevity is ensured: tag records should be available on a centrally coordinated, permanent data base; and most importantly, a means should be provided to detect archival tags by the wide range of groups who might encounter tagged turtles.

Fecundity Clarification

Fecundity estimates for wild and headstarted turtles are available from existing data, but there are a number of divergent estimates which need clarification. Furthermore, when/if headstart turtles are demonstrated to nest, it will be important to obtain accurate fecundity values for them to evaluate their fitness when compared to wild turtles.

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APPENDIX I

The ability to determine survival rate for Kemp's ridleys will be strongly influenced by sample size. To calculate sample size requires at least an approximation of what the survival rate might be; an acceptably low error rate (which must be lower than the survival rate; information on the tag retention rate; what percent of the hatchlings will return to the nesting beach, as opposed to nesting somewhere else; and the probability of encountering a nesting turtle on the nesting beach. For this example of predicted sample size we used the following assumptions:

1) All turtles retain at least one identification mark (tag) until maturity.

2) Imprinting of the headstarted turtles is successful (i.e. 100% of the surviving imprinted turtles will return to Rancho Nuevo location of imprinting, assuming that location is being monitored for marked nesters).

3) The probability of encountering a nesting turtle on the nesting beach is known.

e[1]	p[2]	n[3]	e	p	n
.0001	.001	383776	.01	.1	3458
.0002	.001	95944	.02	.1	865
.0003	.001	42642	.03	.1	385
.0004	.001	23986	.04	.1	217
.0005	.001	15352	.05	.1	139
.0006	.001	10661	.06	.1	97
.0007	.001	7833	.07	.1	71
.0008	.001	5997	.08	.1	55
.0009	.001	4738	.09	.1	43
.001	.01	38032	.01	.5	9604
.002	.01	9508	.02	.5	2401
.003	.01	4226	.03	.5	1068
.004	.01	2377	.04	.5	601
.005	.01	1522	.05	.5	385
.006	.01	1057	.06	.5	267
.007	.01	777	.07	.5	196
.008	.01	595	.08	.5	151
.009	.01	470	.09	.5	119

[1] e = the maximum error rate.
[2] p = the assumed survival rate to maturity.
[3] n = the required number of turtles to be marked.