CENSUSING MANATEES

A Report on the Feasibility of Using
Aerial Surveys and Mark and Recapture Techniques
to Conduct a Population Survey
of the West Indian Manatee.

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RECOMMENDATIONS

(1) Development of tagging methodology should be initiated immediately, due to the time that will be needed to produce a suitable system. Since manatees are so long-lived, tag loss must be minimal. External tags seem most desirable.

(2) Since movements are poorly known, but may be extensive seasonally, a limited number of "peduncle" tags should be deployed as soon as possible to provide the data needed for planning more extensive tagging, censusing, and for many other purposes.

(3) Counts at warm water refugia, available for the last 5 years, should be developed into an index of abundance by further analysis of the counts and auxiliary information (most importantly, temperatures). Other refugia should be incorporated into the index system as soon as possible. Differences in water turbidity and other factors should be considered in devising units or strata for index counts.

(4) It does not seem prudent, or cost-effective, to attempt a state-wide census in the immediate future since so little is known of movement patterns and because various aspects of census methodology need to be worked out. Nonetheless, the proposed indices should be used as the basis for developing a census method. A careful review of the available data should be published to pave the way for revised population estimates, which will quite certainly exceed the number (1000) now widely accepted.

INTRODUCTION

This report results from an invitation to review the needs and prospects for capture-recapture and aerial census studies of the manatee (Trichechus manatus) in Florida. The author visited Florida on May 2 through 6, 1982, under auspices of the U.S. Fish and Wildlife Service. Arrangements for the visit were made by Dr. Franklin Percival, of the Cooperative Wildlife Research Unit at the University of Florida in Gainesville. Dr. Galen Rathbun and the staff of the Gainesville Field Station of the Denver Wildlife Research Center provided both data and guidance, as did P. M. Rose of the Florida Audubon Society (currently manatee recovery activities coordinator for the Fish and Wildlife Service). Three aerial reconnaissance flights provided a first hand view of manatee habitats, as follows: May 3, Suwannee River to Kings Bay and Crystal River (Rathbun, Eberhardt), May 4, Vero Beach to Ft. Lauderdale and Ft. Myers by way of Whitewater Bay (Rose, Percival, Eberhardt), and May 5, Cape Canaveral to Jacksonville, St. Johns River and Blue Spring (Rose, Kinnaird, Eberhardt).

This report takes a somewhat broader view of the census and marking questions than was originally requested, in an effort to provide a better perspective for research planning and coordination. It is difficult to find an example of a marine mammal census that is not subject to a number of uncertainties as to validity of the estimates. Some of the many difficulties have been reviewed by Eberhardt, Chapman and Gilbert (1979). In the absence of much assurance that "good" census techniques are readily available, it is prudent to look rather carefully at circumstances and purposes before choosing a course of action. It should be anticipated that the procedures selected may require 5 years or more for development and implementation.

BACKGROUND AND ISSUES

On the basis of a 1976 survey (Irvine and Campbell 1978), size of the Florida manatee population is frequently reported as being about 1000 individuals. Evidence from that work and subsequent studies have provided evidence that the survey estimate was quite certainly well below the actual population size. The chief difficulty in an aerial survey of the type used is that many of the manatees would not be counted in consequence of the large and varied areas to be covered, overhanging vegetation, dark and turbid waters, and the bottom-resting habits of the species. The census difficulties are well known to the scientists involved. Repetition has nonetheless led to a widespread perception that the population is in the neighborhood of 1000 animals. It can thus be expected that an improved estimate will lead to some confusion and controversy, since reported abundance could very well increase over the years, while actual numbers might be decreasing.

Packard (1981) and Shane (1981) have reported population estimates or counts on the order of double the counts in warm-water refugia in their respective study areas, while the corresponding power plant counts in those areas are substantially higher than the tallies recorded by Irvine and Campbell (1978). The Canaveral-Orlando counts (Table 1) have averaged 126 manatees in recent years, where Irvine and Campbell show 75. Similarly, Irvine and Campbell (1978:615) used a count of 62 manatees at the Riviera Beach plant, whereas the subsequent 5 year average maximum count (Table 1) is 116 manatees. Direct comparisons are thus 242/137 = 1.77 for power plant counts, with a further multiplier up to double that ratio. However, questions as to seasonal movements and methodology may require some conservatism in applying yet another factor of two -- but, on the other hand, estimates based on aerial counts are often substantially under true totals. Hence an accurate estimate of the manatee population could quite conceivably triple the number in current use. Hartman (1974:207) believed that 1000 was the "conceivable maximum" population size. His Figures 33 and 34 should, however, be contrasted with more recent estimates for specific locales. A much more detailed and thorough review of the available data is essential, and the calculations given above are intended only to indicate the need for such a review.

An effective manatee "salvage" program has resulted in tallies of more than 100 mortalities in a number of years. Certainly not all dead manatees are found. If the prevalent population estimate is accepted, the observed mortality may be more than the low reproductive potential of the species can support. Not enough is known about some of the essential population parameters for an accurate determination, but a rough assessment of population dynamics will be given below.

The difficulties in providing accurate (unbiased) estimates of both absolute abundance and of total annual numerical losses are such that both goals may not be achieved for many years, if at all. Alternatives are feasible, and need to be considered, especially in short-term planning. Since manatees are quite vulnerable to several features of expanding human populations in Florida (boating and habitat alterations in particular), it does seem likely that long-term planning should include development of reliable methodology for estimating absolute abundance.

PROSPECTIVE APPROACHES

Since manatees have low reproductive rates, assurance of long-term stability of the population likely requires monitoring of adult survival rates. Unless these rates remain high, the population cannot persist (Eberhardt and Siniff (1977) give an analysis of the relative importance of various population parameters in influencing population growth rates). It is thus important to consider monitoring survival rates through a marking program. The existence of an efficient carcass recovery program provides the necessary machinery of recovering tags.

Table 1. Maximum aerial counts of manatees at power plant sites, 1977 to 1982. 1977 to 1979 data, are from Rose and McCutcheon (1980), 1980 data from Raymond (1981), and 1981 data are from P. M. Rose (pers. comm.).

Power plant	1977-78	1978-79	1979-80	1980-81[a]	1981-82[a]
Riviera Beach	68	99	108	102(141)	201(168)
Hobe Sound	56	97	38	39(50)	35(64)
Total	124	196	146	141(191)	236(232)
Cape Canaveral	83	82	75	102	120
Orlando Utilities	42	31	41	36	16
Total	125	113	116	138	136
Ft. Lauderdale	36	27	36	52(54)	19
Pt. Everglades	114	125	86	110	57(80)
Total	150	152	122	162(164)	76(99)
Ft. Myers	271	172	142	136	127

[a]Editorial Note: Figures in parentheses are corrections that are consistent with 1980-81 data on pg. 22, 32 of Raymond (1981) and 1981-82 data on pg. 23, 29 of McGehee, M. A. (1982. Manatees (*Trichechus manatus*): Abundance and distribution in and around several Florida power plant effluents during the winter of 1981-82. Prepared for Florida Power and Light Co. Miami, FL. 67pp.). The maximum counts at adjacent sites were not necessarily made on the same day, so if there was movement between sites, some manatees may have been counted twice in the totals. JMP 5/9/83

Methods for estimating survival rates from tags or bands taken from dead animals have been rather extensively developed in applications in ornithology, wildlife management, and in fisheries. In most applications, both marking and recovery over a number of years is required if acceptable accuracy (unbiased estimates) and precision (small variance) are to be achieved. Some further discussion on these points will be provided below.

Marking manatees will have further benefits in various ways, including possibilities for direct estimation via capture-recapture methodology, "correction factors" for aerial surveys, and delineation of population units and of movement patterns. Since the major mortality factors quite certainly are more intense in some areas than others, knowledge of local populations and of movements is of substantial importance. Because an efficient and economical marking method is not currently available, an appreciable development time may be required. An enumeration of some prospects appears below.

Because an extensive manatee marking program will undoubtedly be essential in the long term, steps should be taken now to develop suitable methods. Results cannot, however, be expected for some years. Meanwhile, there is a need for current information and for an indication of trends in manatee populations. The possibility of developing a census method without permanent marking will be discussed below. At best, however, such a program might be started in the near future, and will provide little or no information on past abundance.

DEVELOPING AN INDEX OF ABUNDANCE

The main prospect for assessing manatee populations in the recent past is provided by the extensive counts in warm water refugia. There have been a variety of such counts, but the longest and most extensive consistent series is that made by the Florida Audubon Society under contract to Florida Power and Light Company, starting in 1977 and continuing to the present. A detailed analysis is beyond the scope of the present study, so that only a few points are covered here.

The counts were made at a series of sites around Florida, and can be supplemented by at least two other sequences of similar data. Aerial tallies were made at approximately weekly intervals from fall to spring, and thus cover the entire period in which warm water refugia are utilized. A simple approach to using the counts is to use the maximal annual count at each site as an index. The resulting data appear in Table 1, and in Figure 1 (which also includes two other sites, Blue Spring and Crystal River). That the counts represent an important potential source of information about the manatee population is evident from the totals (Table 1). Clearly, a substantial fraction of the population is represented in the totals.

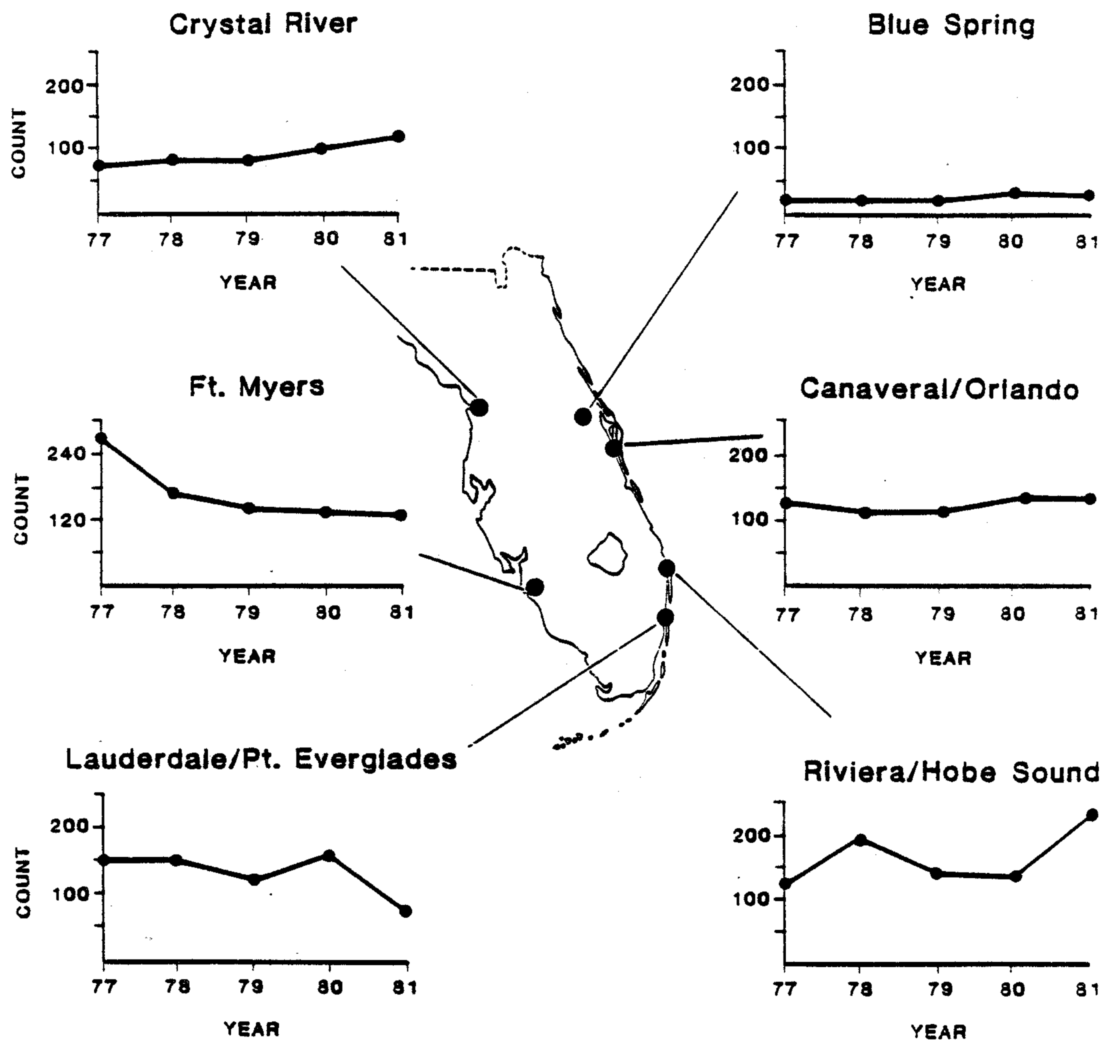

Figure 1. Counts of manatees at warm water refuges. Blue Spring Run data are total identified individuals, all others are maximum aerial counts. Blue Spring and Kings Bay counts are from staff of Sirenia Project, USFWS, Gainesville, Florida. Other data are from Table 1.

Biases very likely exist in the simple index suggested here, and various such prospects are discussed in the several reports on the original data collection. In view of the potential utility of an index constructed from these counts, it would appear worthwhile to devote a substantial effort to seeking ways to compensate for possible biases. One of the major known influences is, of course, temperature. Using temperature as an auxillary variable, possibly "lagged" in time, may provide a route to an improved index. It is also possible that such an adjustment might make it feasible to extend the index to include some earlier counts, including those of the 1976 survey, made over a short time period. This is well worth the trouble, inasmuch as the winter of 1976-77 was reported to be the severest on record, and some cold-related mortality occurred then (Brownell 1980).

Various investigators have remarked that manatees appear to somehow anticipate cold weather, or may follow a seasonal cycle, possibly related to photoperiod. If this is true, the direct association with temperature may show some seasonal differences, depending on the annual variation in temperature patterns. One useful analytical technique will be to regress counts on temperature and then plot the residuals (deviations from regression) against time, and contrast these plots between sites in the same year and between years for the same site. Non-linear least-squares fits to various models may also be useful, and data that have been classified as to counting conditions may be most useful. While a general seasonal pattern may emerge, it should not be expected that the regression relationship will be the same at all sites, due to local conditions and latitudinal effects.

In the absence of unbiased population estimates, with which index data might be "calibrated", one cannot be sure that a particular kind of adjustment does in fact improve a "crude" index, such as the maximum count suggested above. About all that can be done is to search for procedures that have a basis in logic, and for which some sort of internal consistency can be demonstrated. Even so, development of an index should very likely be regarded as the first step in a series aimed at ultimately producing an unbiased population estimate. In the present example, one such step may be to make a series of counts well away from the refugia. If the time trend at warm water refugia is accurately mirrored by an inverse pattern away from the refugia, and both are correlated to temperature change, one may feel justified in relying on the index. Figure 2 shows the data for counts at Riviera Beach power plant (Packard 1981) contrasted with counts in the surrounding area. It seems evident that there was an influx of manatees to the region in mid-December. Hence the counts "away from" a refugium may well need to encompass a very large area. Other prospects for checking on an index will likely become evident as increasing numbers of marked animals become available in the population.

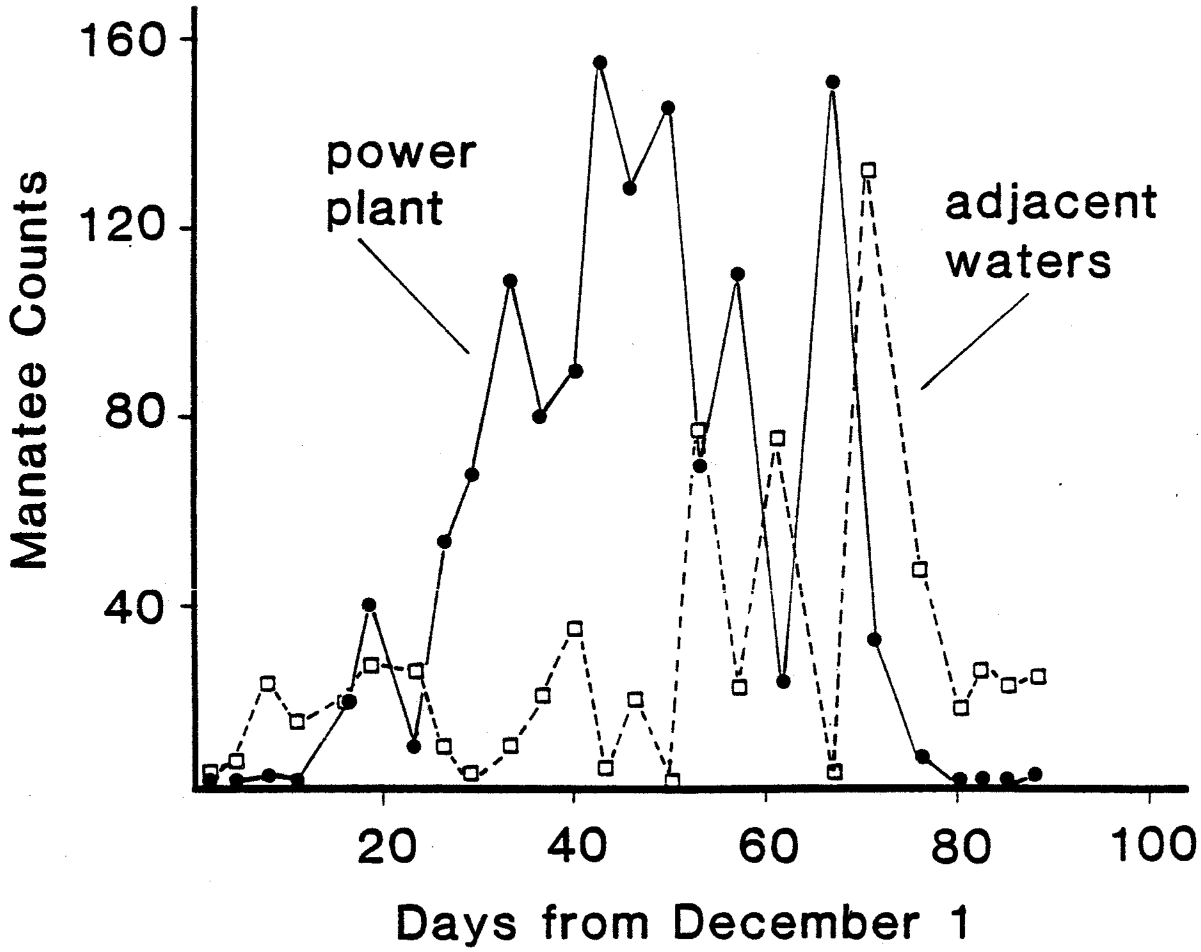

Figure 2. Counts of manatees at the Riviera Beach power plant compared with those in adjacent waters, December 1980 through February 1981. Data are from Packard (1981).

The mortality data and the 1976 statewide survey give some further indications as to possible population status and survey needs. Total mortalities by county from 1979 through 1981 (C. Beck, letter of 13, May 1982) appear in Figure 3. The high loss in Brevard County is well known and under study. As yet, it does not appear to have influenced counts at the nearby power plant sites (Figure 1). It is, of course, possible that these losses may influence populations associated with much of the eastern part of the state. Mortality in Lee, Collier, and Monroe counties is also substantial and is associated with a declining trend at the Ft. Myers power plant, plus the large loss in Lee County in 1982 (41 manatees through May 10, 1982). It can thus be supposed that detailed population studies in this southwestern region very likely should have high priority. It is apparently not known how well the Ft. Myers counts represent populations further south, since these "southern" animals may have less reason to seek winter refuge at power plants.

The Collier-Monroe County area is clearly a difficult region to census, due to the opacity of the water there, extent of the water areas, and convoluted shoreline. Nonetheless, in the 1976 survey (Irvine and Campbell 1978), 163 manatees were observed (Jan. 29-Feb. 3), while Irvine et al (1981) tallied 149 in November of 1979. In the 1976 survey, 91 manatees were counted in the Ft. Myers area on January 30. The high counts in the Ten Thousand Islands - Whitewater Bay area in spite of difficult counting conditions suggest that the manatee population there is probably a large one. Against this should be set the declining trend at Ft. Myers and the high loss in that area this year. Next winter's count at Ft. Myers is thus a very important datum in evaluating this situation. Very likely a high priority should be assigned to marking manatees at Ft. Myers, and monitoring for marked animals throughout the southwestern area.

Mortality records in the Tampa Bay area (10) plus the 1976 survey count there (43) suggest that some consideration might be given to establishing a monitoring system there. Similarly, the St. Johns River and Jacksonville area appear to need more attention, with 33 mortalities and little data on the warm-water refugia in the Jacksonville area. Opacity of the water is again a major problem, and the main indication of trend in the region (counts at Blue Spring Run) shows evidence of a general upward trend. Surveys of various refugia on the upper St. Johns River (Anon. 1981) suggest little prospect of substantial numbers wintering outside Blue Spring Run, so the remaining questions may have to do with numbers wintering in the Jacksonville area and with possible migration southwards along the Atlantic coast. Bengtson (1981) telemetered 15 manatees in Blue Spring Run and did not observe any indication of these animals travelling to the Atlantic. However, he estimated the manatee population of the St. Johns River to be 50-75 animals, a figure that is not consistent with the observed recent average mortality (11 per year) and the increasing trend of numbers at Blue Spring. Very possibly the main population at Blue Spring is rather permanent and largely independent of the animals in the Jacksonville area. Some "transients" are regularly reported at Blue Spring (Anon. 1981).

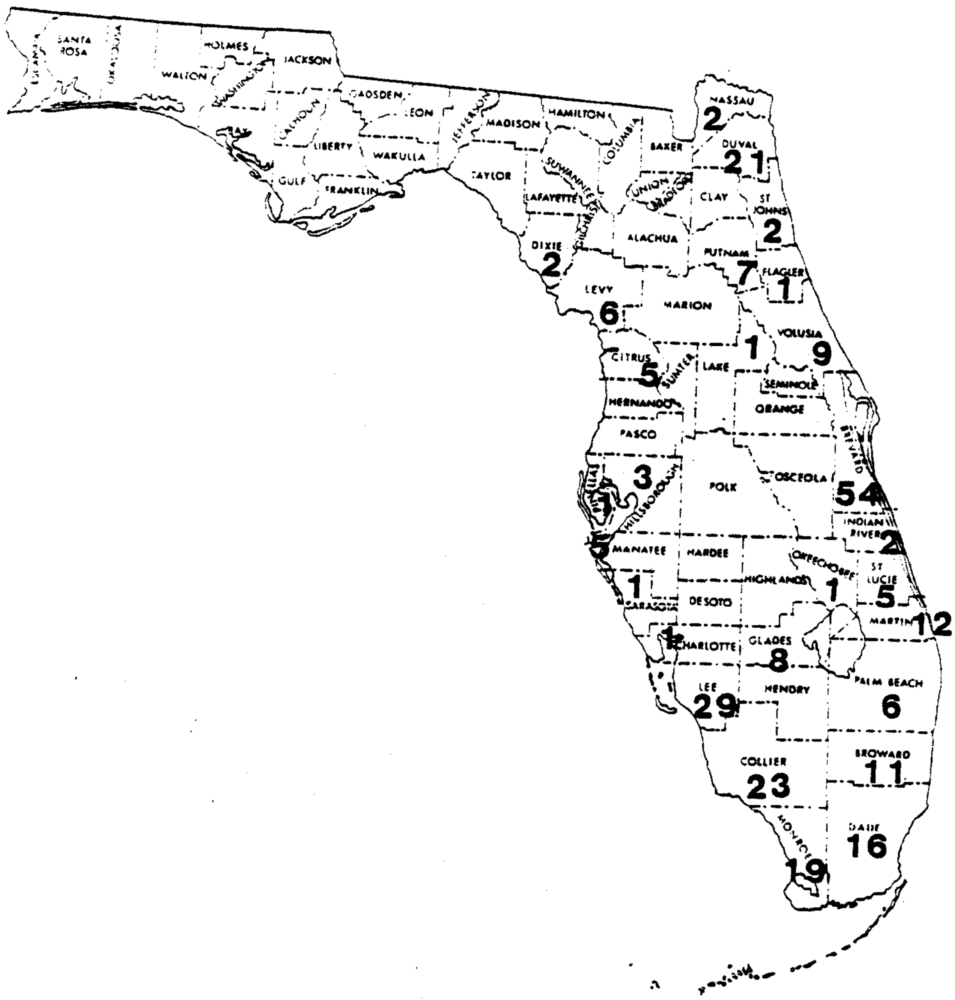

Figure 3. Recorded manatee mortalities by county, 1979 through 1981. Data from Sirenia Project, USFWS, Gainesville, Florida.

Several other sites, including Lake Okeechobee and Blue Lagoon may need to be incorporated into an "index" system.

ESTIMATING ADULT SURVIVAL

The essential features of the dynamics of manatee populations are not known with any accuracy. Two individuals, observed since birth, were in late pregnancy at age 5 at Crystal River. For adult animals, the interval between births is generally between 2 and 3 years, with a current average of about 2.5 years (Rathbun pers. comm.). Female births per female would thus be about .5(1/2.5) = .2, assuming an even sex ratio, as has largely been observed thus far. Referring to Fig. 2 of Eberhardt and Siniff (1977), it can be inferred that the annual survival rate required for an equilibrium (constant) population level quite likely is appreciably greater than 0.90. From the figure, age of first reproduction is likely not to have a major impact on this estimate.

Survival for the first year or two is generally not known for marine mammals (in the graph referred to above, survival to age 3 was assumed to be half of the adult rate). No doubt continued close observation at Blue Spring and Crystal River will yield an estimate of calf survival in time, and thus a basis for some improved calculations. However, calf mortality is no doubt substantially higher in other areas, where populations are in more jeopardy from boats and barges.

Some further calculations of likely rates are worthwhile, using the fairly widely observed fraction of calves in the population (about 9 or 10 percent in much of the data), and possibly the model suggested in Eberhardt et al (1982), which has been revised to take senescence into account. Although there are no observations on senescence in manatees (or in most marine mammals), an arbitrary truncation at some advanced age may be preferable to using the assumption of constant adult survival regardless of age assumed in the graphs given by Eberhardt and Siniff (1977).

A detailed review of the methodology for estimating survival is beyond the scope of the present report. As noted above, the procedure suggested for manatees involves recovery of tags or marks in carcasses obtained through the "salvage" program. Since the carcasses could be examined radiographically, an externally visible mark is not necessary, and it has been suggested that a mark operating on the principal of the magnetic fish tag might be somehow injected in the caudal appendage ("paddle"). This will involve some complexities in the form of detection equipment and possibly in encoding tags for identity. Application to free-swimming animals requires a simple and rapid method. Multiple marks may need to be used due to prospects of loss of marks, and the best approach may be to use compressed gases to inject a number of marks into the caudal appendage.

At a minimum, marks need to be distinguishable by year of application, and there would be various advantages to identifying individuals. However, the best prospect for applying substantial numbers of marks is in the concentrations of animals observed in warm-water refugia. If marks cannot be identified visually, the observations will consist of a time and place of recovery, plus either a time and place of marking, or only a time (year) of marking. Some further analysis is worthwhile to examine the likely utility of place of marking with respect to an auxiliary program in which externally visible marks are used, thus providing opportunities for multiple observations on individuals.

In any case, the marks need to be identified to at least year of application, and a number of years of application will be needed (see below). The question of coding by place of application may thus be considered with respect to the number of codes available. One of the prospects for a mark may be steel shot, coded by using different alloys might then be a limitation. An alternative that has been suggested is to use numbered "fingerling" tags, in which case many individuals can be identified, possibly at the cost of poorer ballistic performance of the marks.

Another problem that needs consideration is the prospect of double-marking of individuals, if there is no external evidence of a mark. This needs to be guarded against in a given year, possibly by incorporating some kind of marking substance in the application process, so as to leave a surface mark. Multiple marking over successive years would likely be unavoidable, but may in fact yield some useful information in itself. This is one of several questions needing further attention, with respect to the underlying models for mark and recovery processes.

The immediate need, of course, is for development of marking technology. Presumably, initial efforts will be devoted to tests on freshly dead specimens, followed by work in oceanaria and at sites where close observation of known individuals is possible. Experience under the Sirenia Project and a series of photographs collected over the years indicate that marking in or through the caudal appendage ("paddle") is likely to be a safe and reliable procedure.

As has been suggested above, results will not be available for some years and will improve in precision with the passage of time, as more and more tags are recovered. If an implanted mark (not visible from the surface) is used, the data will be similar to that obtained from a variety of marking schemes. Possibly the closest parallel is with bird-banding of non-hunted species. The data will differ from the usual such situation in that manatees are much more long-lived than most birds. There are, however, parallels in some of the larger oceanic birds. For example, Cormack (1964) gives annual survival estimates of 0.94 to 0.97 for the fulmar petrel (*Fulmarus glacialis*). In many of the bird-banding studies, there are questions about the consistency of the recovery effort, and the degree of non-reporting of bands. In the present situation, minimization of problems of this nature will depend on maintaining the present manatee "salvage" effort at a high and consistent level of efficiency. Such a scheme cannot be shut down and then re-activated as it is needed, due to the many difficulties of achieving agency and public cooperation.

There is now a substantial literature on survival estimation from tag recovery data, much of which is concerned with bird-banding. An extensive handbook (Brownie et al 1978) provides an array of structural models, and some guidelines for planning a study. It is particularly important to note that this extensive effort is based on the assumption that no bands are lost between application and recovery. Since manatees can be expected to have a high survival rate (over 90 percent per year, as noted above), even a highly efficient recovery system will still only yield a few returns per year -- probably less than 5 per 100 marks applied. It will thus require a substantial number of years before enough marks are recovered to yield the kind of information that may be needed. Hence the marking scheme needs to be virtually "foolproof" in assuring that a marked animal is identified as such on recovery. However, all animals with major damage at the marking site (e.g., the caudal appendage) can simply be excluded from consideration and thus that aspect of reidentification probably needs not be a matter of major concern. The critical issue is that of possible unobtrusive loss of marks or of overlooking marks on examination of dead manatees.

While references such as Youngs and Robson (1975) and North and Cormack (1981) should be consulted for a basis for a detailed evaluation of sample size requirements, a rough idea of the "variance problem" may be obtained from results given by Chapman and Robson (1960) by considering recoveries from a single year of marking (the reference actually considers estimating survival from age structure data, but the results apply also to band recoveries, given the usual assumptions). Chapman and Robson (1960: eq. (5) or eq. (7)) give a variance estimate appropriate when all of the tagged animals are dead (i.e. a "complete" series of recoveries) and one for a truncated series (eq. (20)), which might be applied during the course of the recovery process (i.e., when only k years have passed, where k is less than the life span of a manatee). The sample size (n) in the incomplete series will be smaller, but can be adjusted for by comparing the ratio of expected sample sizes (incomplete series/complete series).

A rather hasty examination of such a comparison suggests the need for a more careful analysis before using internal tags, identifiable only on the death of the animal. Visible tags, if coded by time (year) of marking, will provide an additional opportunity for estimating survival (through resighting) as well as essential information on movements and the prospect of estimating total numbers. A general impression is that the human-caused mortality problem may be most important in particular areas. It is consequently very important to know whether there are fairly discrete sub-populations in these areas, or whether there is a substantial movement of manatees over large portions of the range. Some evidence of long distance movements exists (Shane 1981).

DIRECT COUNTS

As has been remarked above, the substantial variability in habitats and visibility conditions argues against an expectation of successful direct counting of manatees over large areas. The notable exception is counting in warm-water refugia, where it may be feasible to devise a workable scheme for censusing through direct counts with correction factors. A key point is that it is known from studies at Blue Spring and Crystal River that some individuals may be absent from a given refuge at any particular time. Hence, although direct counts might be corrected for animals not visible at the time of counting, there may be another component of the population to be accounted for in censusing.

Very likely, the question of whether or not direct counts should presently be attempted has to be resolved in terms of the urgency attached to "getting a number". Since manatees are long-lived and quite possibly follow a rather fixed annual cycle of movements, a successful marking scheme, necessary for estimating survival, should ultimately also yield good data on numbers.

The sizable numbers of manatees counted through aerial surveys over power plant effluent discharge areas suggest that these counts may provide the starting place for attempts to develop a census methodology. Since sighting and flying conditions vary from site to site, a detailed study of several such sites may provide the optimal first step in developing a method. An initial question is that of the fraction of the animals present that are actually seen from the air, determined by some sort of "ground truth" operation. If locations of manatees sighted from the air are mapped, then it may be feasible for shore-based observers to locate, in advance, groups of manatees in distinctive locations, and to keep them spotted while the aerial count is made, as has been done for sea otters in California. Some extensive experimentation will be required to determine whether such a scheme is feasible for manatees and sufficiently efficient.

The difficult conditions will, of course, be those where turbid water has to be dealt with. No doubt some kind of identification of individual animals will be required in the most difficult sites, and costs may then be excessive. However, an essential first step is a sufficiently detailed inventory of sites and local conditions, plus an appraisal of the likely sequence in which census operations should be undertaken. That is, there is little prospect for producing a fully satisfactory estimate of the entire manatee population in a year or two. There may be, however, a good prospect for developing a satisfactory index to abundance and for improving that index in the direction of converting it to a census in the future.

Some work on a temporary sonic tag may be worthwhile. Quite possibly some sort of "hedgehog" sonic tag would stay in place long enough to be useful in correcting direct counts. Probably the thick and tough integument of a manatee would not be damaged by the impact of an attachment surface having many short and possibly barbed bristles. Such a device would require an appreciable amount of development and testing, but it appears that census work in the most heavily obscured waters will require either an "active" tag or acoustic "fish-finding" techniques.

Improving the accuracy of counts in warm water refugia does not resolve the census problem if there are significant numbers of manatees present away from these areas when the peak counts are made. Some data on this point are available, and more can be collected. An important feature of the high counts in warm water refugia is that they are temporary phenomena, and that a substantial fraction of the population may be thus concentrated. Under such circumstances, it may be possible to utilize the resulting change in counts away from the refugia to provide an estimate of population size. A recent description of a "removal" method for estimating abundance is available in Eberhardt (1982). The circumstances here are different, but the same principle may well apply. A critical issue may be the variability in replicate counts away from the refugia when much of the population is concentrated in the warm-water area. Since these counts will presumably steadily decrease as the counts at warm water refugia increase, some sort of regression model may be useful in an estimation scheme using the "removal" principle.

CAPTURE-RECAPTURE METHODS

Capture-recapture estimates may be attempted on the basis of two marking methods. One would use the tags developed for survival estimation, assuming that these are external and color-coded to at least year of application. The second would be based on recognizable scar patterns of individual manatees. Some experience is now available on use of scar patterns at Blue Spring, Crystal River (Rathbun, pers. comm.), Brevard County (Shane 1981), and in Hobe Sound (Packard 1981). The experience at Blue Spring shows that a file of photographs is an essential adjunct to use of scar patterns for identification, due to the difficulty of producing unambiguous sketches of various features (Rathbun pers. comm.). Effective use of scar patterns requires both clear water and good access to individual manatees. Continued participation by the same small group of experienced observers is also essential. Rathbun (pers. comm.) notes the history of the Crystal River and Blue Spring populations as a case in point. In the early records of identities of individual manatees there appears to be a considerable change in composition, while the recent records (kept by a few people using the photo file) show little turnover.

Research on the utility of scar patterns as "tags" is needed, particularly by way of verifying accuracy of identification. The few tests done thus far have involved matching photographs. It would be worthwhile to develop a series of photographs for that purpose by taking sequences of photos of the same individuals, so that there is no question that the photos are of the same animal. Photos of tagged individuals might also be used, with the tags blocked out. A considerable amount of attention should be paid to the statistical design used in presenting such a series of photos to investigators, and opportunities should be sought to test scar pattern identification in a "closed" population (i.e., in an area with a confined population). Tests in the field are of course to be preferred to work with photos.

Planning for a large scale capture-recapture study will depend on a better understanding of manatee movement patterns. As remarked above, it may well be desirable to do some immediate marking with "peduncle tags" to obtain preliminary data on movement patterns and exchange between regions. If such work were initiated now, results could be available by the time a suitably efficient tag has been developed. Also, the movement data obtained from a limited number of peduncle tags might make it feasible to do more work on local populations based on scar pattern recognition.

Marking presumably would most efficiently be done in warm-water refugia. Resighting in the same areas raises the question of biases due to non-representative sampling of the population. Assessing the likely nature and extent of such biases will require a better understanding of seasonal movement patterns (and hence requires marking). Most likely, population estimates will have to be built up over a number of years and, in common with survival estimates, will depend on continuing introduction of marks. With such a scheme, there is a prospect of estimating survival through the Seber-Jolly equations. Some modifications will be required to allow for the fact that resighting rather than recaptures provides the primary data, and new marks are introduced in annual "batches". Some experience with such a scheme is available in Siniff et al (1977).

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