

(Ackerman, 1995). These surveys are much more comprehensive than those used to estimate a minimum population during the 1980s. The highest statewide, minimum count from these surveys was 3,276 manatees in January 2001; the highest count on the east coast of Florida included 1,814 animals (January 2003) and the highest on the west coast included 1,756 (January 2001).

Due to the problems mentioned above, we do not know what proportion of the total manatee population is counted in these surveys. These uncorrected counts do not provide a basis for assessing population trends, although trend analyses of temperature-adjusted aerial survey counts may provide insight to general patterns of population growth in some regions (Garrott *et al.*, 1994, 1995; Craig *et al.*, 1997; Eberhardt *et al.*, 1999).

It is possible, however, to monitor the number of manatees using the Blue Spring (Volusia County) and Crystal River (Citrus County) warm-water refuges. At Blue Spring (in the Upper St. Johns River Region), with its unique combination of clear water and confined spring area, it has been possible to count the number of resident animals by identifying individual manatees from scar patterns. The data indicate that this group of animals has increased steadily since the early 1970s when it was first studied. During the 1970s the number of manatees using the spring increased from 11 to 25 (Bengtson, 1981). In the mid-1980s about 50 manatees used the spring (Service, 2001), and by the winter of 1999–2000, the number had increased to 147 (Hartley, 2001).

In the Northwest Region, the clear, shallow waters of Kings Bay (Citrus County) have made it possible to monitor the number of manatees using this warm-water refuge at the head of Crystal River. Large aggregations of manatees apparently did not exist there until recent times (Service, 2001). The first careful counts were made in the late 1960s. Since then, manatee numbers have increased significantly. From 1967 to 1968, Hartman (1979) counted 38 animals in Kings Bay. By 1981–1982, the maximum winter count had increased to 114 manatees (Powell and Rathbun, 1984), and in November 2000, the maximum count was 301 (Service, 2003).

Both births and immigration of animals from other areas have contributed to the increases in manatee numbers at Crystal River and Blue Spring. Animals may be further attracted to these areas because of local manatee protection areas. Three manatee sanctuaries (areas in which waterborne activities are prohibited) in

Kings Bay were established in 1980; an additional three were added in 1994, and a seventh in 1998. The increases in counts at Blue Spring and Crystal River are accompanied by estimates of adult survival and population growth that are higher than those determined for the Atlantic coast (Eberhardt and O'Shea, 1995; Langtimm *et al.*, 1998; Eberhardt *et al.*, 1999).

While aircraft synoptic surveys provide a "best estimate" of the minimum Florida manatee population size, there are no confidence intervals (derived through reliable, statistically based, population-estimation techniques) for these estimates. With the exception of a few places where manatees may aggregate in clear, shallow water, not all manatees can be seen from aircraft because of water turbidity, depth, surface conditions, variable times spent submerged, and other considerations. Thus, results obtained during typical manatee synoptic surveys yield unadjusted partial counts. While these results are of value in providing information on where manatees occur, likely relative abundance in various areas, and seasonal shifts in manatee abundance, they do not provide good population estimates, nor can they reliably measure trends in the manatee population. Consequently, the Florida Manatee Recovery Plan (Service, 2001) concludes that "despite considerable effort in the early 1980s, scientists have been unable to develop a useful means of estimating or monitoring trends in size of the overall manatee populations in the southeastern United States."

Population models employ mathematical relationships based on survival and reproduction rates to estimate population growth and trends in growth. A deterministic model (a model in which there are no random events) that uses classical mathematical approaches with data on reproduction and survival of living, identifiable manatees suggests a maximum population growth rate of about 7 percent per year, excluding emigration or immigration (Eberhardt and O'Shea, 1995). This maximum was based on studies conducted between the late 1970s and early 1990s in the well-protected winter aggregation area at Crystal River and did not require estimation of the population size. The analysis showed that the chief factor affecting the potential for population growth is survival of adults.

Estimated adult survival in the Atlantic Region (a larger region with less protection) has suggested slower or no population growth between the late

1970s and early 1990s. This modeling shows the value of using survival and reproduction data obtained from photo-identification studies of living manatees to compute population growth rates with confidence intervals, providing information that can be used to infer long-term trends in the absence of reliable population size estimates. Collection of similar data has been initiated only recently in that area of Florida from Tampa Bay to the Caloosahatchee River (beginning in the mid-1990s) and none is available for many of the remaining areas used by manatees in southwestern Florida (Southwest Region).

A population viability analysis (PVA), in which random events, such as red tide and extremely cold winters, are incorporated into a model, was carried out for manatees based on age-specific mortality rates estimated from the age distribution of manatees found dead throughout Florida from 1979 through 1992 (Marmontel *et al.*, 1997). This method of estimating survival relied on certain assumptions that were not fully testable; despite this, the results again pointed out the importance of adult survival to population persistence. Given a population size that reflected a 1992 minimum population estimate, the PVA showed that if adult mortality as estimated for the study period were reduced by a modest amount (for example, from 11 percent down to 9 percent), the Florida manatee population would likely remain viable for many years. However, the PVA also showed that slight increases in adult mortality would result in extinction of manatees within the next 1,000 years.

The above review demonstrates that using statewide population size "estimates" of any kind is scientifically weak for estimating population trends in manatees. The weight of scientific evidence suggests that the potential for population increases over the last two decades is strong for two protected aggregation areas. New population analyses, based on more recent (since 1992) information, are not yet available in the peer-reviewed literature.

In 2001, the Manatee Population Status Working Group (MPSWG) provided a statement summarizing what they believed to be the status of the Florida manatee at that time (Wildlife Trust, 2001). The MPSWG stated that, for the Northwest and Upper St. Johns River regions, available evidence indicated that there had been a steady increase in animals over the last 25 years. The statement was less optimistic for the Atlantic Region due to an adult survival rate that was lower than the rate necessary to sustain population