Executive Summary

Florida's Wildlife Commission has gathered red tide data collected since 1953. The database contains 64,053 records provided by 78 collecting agencies. A review of the data indicated that the collecting agencies have widely varying numbers of observations, years of collection, spatial areas of collection, and sampling effort (monitoring, event-response, other). The variables available for analysis are spatial location, sampling date, collecting agency, depth of collection (for most observations), and either *K. brevis* counts or presence/absence. Questions about decadal patterns or other long-term behavior cannot be answered given the inconsistent pattern of spatial area sampled over time. Similarly, questions concerning increased area of intense blooms cannot be addressed. Analyses of long-term studies require that data be collected in a similar fashion and with similar spatial and temporal densities over a long period in order to ascribe fluctuations in intensity to large-scale patterns such as might be due to El Nino effects. Likewise, studies of bloom behavior in the shorter-term require regular monitoring at stations in a sufficiently dense spatial configuration and over an area that is sufficiently large to capture the scale of the blooms. Event response data do not provide a foundation for such studies. The numbers of samples with *K. brevis* present was highly correlated with the total numbers of observations taken over time. However, when the odds of presence were considered, the odds reflected an almost cyclical nature and a tendency to either remain constant or to decrease slightly over time. Care must still be taken when interpreting this result because the extensive event-response data present would tend to inflate the odds, and this is a greater concern in time periods with larger proportions of event-response data.

The data are too sparse in both time and space to address whether *Karenia brevis* blooms have increased in frequency in the past 50 years. However, three subsets of the data were found that were dense enough in both time and space to permit the probability of *K. brevis* exceeding 5000 cells/liter to be modeled on a more limited scale. In these three cases, there was no evidence that the probability of observing levels of *K. brevis* above that which leads to closing the shellfish beds is increasing through time. In one instance (Tampa Bay), there was no change through the years. In the other two cases (USFWS, 1953 to 1961, and Mote (MMR) and FWRI, 2001 to 2005), the probability tended to decrease slightly though time.

In addition to these three datasets, we found a small spatial region that had sufficient numbers of observations for a longer time period that could be studied in a limited fashion for temporal changes in severity. The region is a 2º square (-84º to -82º west and 26.5º to 28.5º north) off of Tampa Bay and Charlotte Harbor in the Gulf of Mexico. The average severity decreased across years at inshore locations post-1965 in all months except February, July, and August; for those three months, average severity was constant across years. Average severity decreased at offshore locations post-1965 in May and August; increased in January and July, and was constant across years otherwise. For pre-1965, average severity increased between 1953 and 1964 inshore in July and August; decreased in November and was otherwise constant. For pre-1965, average severity increased between 1953 and 1964 offshore in April, July and August; decreased in December and was other constant. To analyze for severity as a function of density, the same analyses were conducted using $\log_{10}$(cells/liter+1) as the response variable. The results were very similar. The average $\log_{10}$(cells/liter +1) decreased across years at inshore locations post-1965 in all months except February, July, August, September, and November; for these months, average

$\log_{10}$(cells/liter +1) did not change significantly across years. Average severity decreased at offshore locations post-1965 in May and August and was constant across years otherwise. For pre-1965, only August through December had sufficient data inshore for testing slopes. Average $\log_{10}$(cells/liter +1) decreased between 1953 and 1964 inshore in October and December and was other constant. For pre-1965, average $\log_{10}$(cells/liter +1) decreased in December and was otherwise either not estimable (January, March, May, and July) or constant (February, April, June, August, September, October, and November).

To fully address the questions of status and trends of *K. brevis*, and to develop a fuller understanding of the "lifecycle" of blooms (initiation, development, movement and deterioration), a comprehensive sampling program should be developed. A tiered approach, such as two-phase or double sampling (Thompson, 2002) may be most effective and economical. In double sampling, the purpose is to have better estimators of the variables of interest by using the relationship between data collected at the first and second phases. In the initial phase of HAB studies, either remote sensing or an underwater glider could be used to identify a level of *K. brevis* warranting more intense study. If remote sensing methods can be used to identify the presence of organisms in the family *Karenia*, this approach offers good spatial coverage but, at present, is unable to record information below the surface. A second phase could then be implemented in which ground-truthing of the remotely sensed data and additional detailed studies could then be performed using the satellite information to guide placement of the sampling locations. The number and choice of sampling locations would depend on the purposes of the data collection. For example, sampling on a regular grid (areal systematic sampling) combined with adaptive cluster sampling (Thompson and Seber, 1996; Christman, 2000) could be used to characterize the extent of blooms. Additional transects, spaced appropriately, with the use of the underwater glider could be used synoptically to characterize meso-scale extent of blooms and the variability within and between blooms. The frequency of obtaining a broad spatial coverage needs to be such that a bloom would not have time to fully develop between sampling times. Developing a sampling program that incorporates both the broad spatial and frequent temporal coverage and more intense sampling when a bloom is identified would require careful planning so that the resulting data could be combined in a manner that leads to statistically valid inference.

References

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