Assessment of the Eastern Gulf of Mexico Harmful Algal Bloom Operational Forecast System: A Comparative Analysis of Forecast Skill and Utilization from 2004 to 2008

Karen Kavanaugh[1]; Kathleen Fisher[1]; and Katherine Derner[2]

[1] *NOAA, National Ocean Service, Center for Operational Oceanographic Products and Services (CO-OPS), Silver Spring, MD 20910*

[2] *NOAA, National Ocean Service, CO-OPS, 672 Independence Parkway, Chesapeake, VA 23320*

Karen.Kavanaugh@noaa.gov

INTRODUCTION

Blooms of the toxic dinoflagellate, *Karenia brevis*, occur nearly every year in coastal regions of the Gulf of Mexico (GOMX) causing potential impacts on public health, ecosystems, and regional economies. To aid early bloom identification and response efforts, in 2004 NOAA transitioned a successful demonstration forecast system for harmful algal blooms (HABs) from research to operational status with coverage along the Gulf coast of Florida. NOAA's GOMX HAB Operational Forecast System (HAB-OFS) issues weekly bulletins that serve as decision support tools for coastal resource managers, federal and state agencies, and academic institutions. In order to continually improve the HAB-OFS, bulletin utilization and forecast skill are evaluated regularly. This comparative analysis focuses on the eastern GOMX and builds upon previously presented assessment data, evaluating the development of the HAB-OFS and advancing skill since the first operational bulletin was issued. Of the 424 total bulletins issued for the eastern GOMX from October 2004 through April 2008, 328 bulletins were issued during a total of 16 confirmed HAB events. Assessment results will be applied to improve HAB forecasts in both the eastern and western GOMX(Texas), which became operational in 2010.

METHODS

Bulletin Forecasts

- Bulletin forecasts consisted of four components: **Transport**, **Intensification**, **Extent**, and **Respiratory Impacts** produced by the bloom. See Table 1 for descriptions.
- Bulletin **Priority Level** (Low-High) assigned based on the need for management response.

Assessment

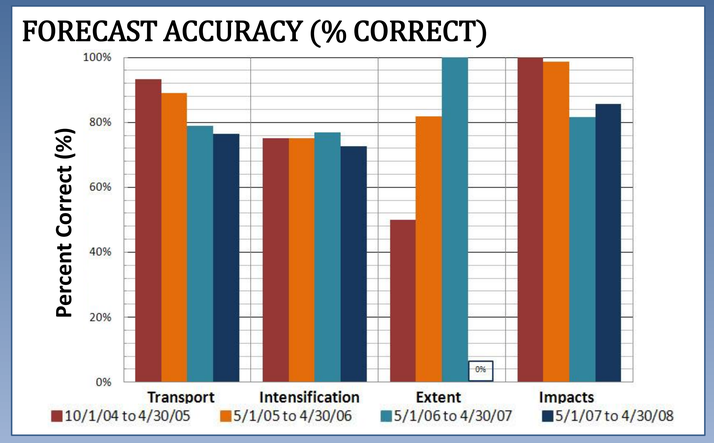
- Forecasts were evaluated for accuracy and usability each week based on the following post-bulletin data:
  - **Bulletin Utilization**: Media or public health reports, sampling response, written/ telephone responses or inquiries, etc.
  - **Transport**, **Intensification**, and **Extent**: Satellite imagery and/or *in situ* sample data.
  - **Respiratory Impacts**: Observations of slight to high respiratory irritation within the forecast area (county) as reported by state agencies and research institutions.
- Assessment data was then grouped by bloom year (BY), e.g. May 1 to April 30, YYYY.

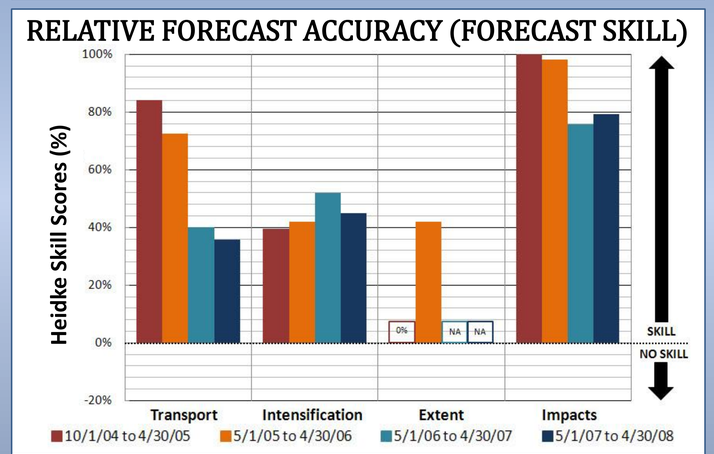
Statistical Analysis

- **Assessability**- % of bulletin forecast components and utilization with sufficiently available evidence for evaluation
- **Forecast Accuracy-** % of correct forecasts out of the total # of assessable forecasts
- **Relative Forecast Accuracy**- ***Heidke Skill Score***- Proportion of correct forecasts relative to the # of correct forecasts that could be made by random chance
- **Bulletin Utilization**- % of bulletins confirmed utilized

FORECAST COMPONENT	DEFINITION	CATEGORIES	FORECAST BASIS
Transport	Direction bloom is likely to migrate	• North • South • No Change	• Forecasted winds • Local ocean currents • Coriolis effect • Ekman transport
Intensification	Expected change in bloom concentration	• Increase • Decrease • No Change	• Upwelling favorable conditions
Extent	Expansion of bloom into a new county	• Increase • Decrease • No Change	• Forecasted winds • Local ocean currents • Coriolis effect • Ekman transport
Impacts	Potential respiratory irritation caused by the bloom	• Very low • Low • Moderate • High • None	• Forecasted wind strength and direction • K. brevis concentration • Bloom proximity

Table 1. Definitions of forecast components for the Florida region.





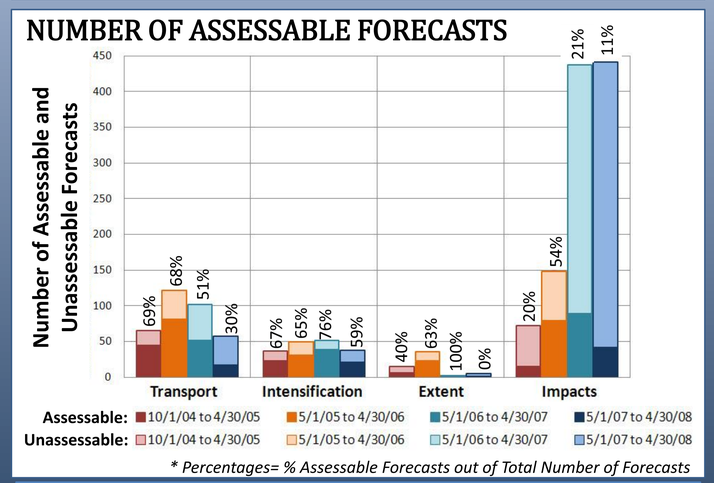


Figure 1. *(from top)* Percent correct forecasts (of total assessable), Heidke skill score (of assessable), and the number of assessable and unassessable forecasts for each forecast component.

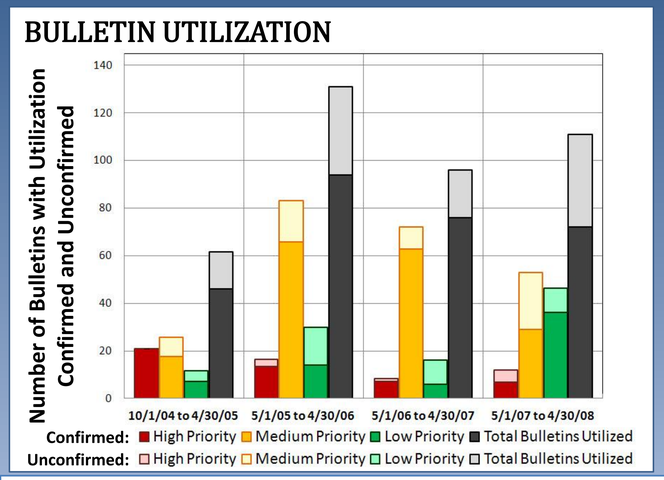


Figure 2. Number of each bulletin priority type for which utilization was confirmed and unconfirmed for each bloom year.

CONCLUSIONS

More Information is Often Needed in order to Assess Bulletin Forecasts and Bulletin Utilization

- Respiratory impact forecasts are the most difficult to assess.
  - Although it was the most forecasted component since BY 2005-2006, many forecasts were unassessable. In the '05-'06 season, <55% of impacts were assessable. In all other years, <22% of impact forecasts were assessable.
  - Availability and spatial coverage of observational data is limited.
  - 13-25% of forecasts were unassessable because impact absence could not be confirmed.
- Since transport, intensification, and extent forecasts can often be verified using satellite imagery in addition to field data, the ability to assess these components is greater, although limited by occasionally obscured imagery (30-100% assessable).

All Bulletin Components are Forecast with High Accuracy and Skill

- Respiratory impact forecasts had the highest accuracy and skill, but the forecasts are biased toward the observation of impacts because observations of "no" impacts are rarely reported.
- Extent forecasts had the least amount of skill, but extent change is rarely foreimpact cannot cast and is difficult to assess. This will be addressed in the future.

Bulletins Successfully Assist Users

- Overall bulletin utilization was >64% each bloom season.
- High Priority bulletins had the greatest proportion confirmed utilized (>87%), followed by Medium Priority bulletins (>69%), with the *exception BY 2007-2008* (both >54%).
- Priority categories successfully identify bulletins that contain highly significant information and conditions for coastal resource managers and other bulletin users.

References

Doswell, C.A., Davies-Jones, Robert, & Keller, D.L. (1990). On summary measures of skill in rare event forecasting based on contingency tables. *Weather and Forecasting*, 5, 576-585.

Fisher, K.M., Allen, A.L., Keller, H.M., Bronder, Z.E., Fenstermacher, L.E., & Vincent, M.S. (2006). Annual Report of the Gulf of Mexico Harmful Algal Bloom Operational Forecast System (GOM HAB-OFS): October 1, 2004 to September 30, 2005 (Operational Year #1). *NOAA Technical Report*, NOS CO-OPS 047.

Stumpf, R.P., Culver, M.E., Tester, P.A., Tomlinson, M., Kirkpatrick, G.J., Pederson, B.A., Truby, E., Ransibrahmanakul, V., & Soracco, M. (2003). Monitoring *Karenia brevis* blooms in the Gulf of Mexico using satellite ocean color imagery and other data. *Harmful Algae*, 2, 147-160.

Stumpf, R.P., Tomlinson, M.C., Calkins, J.A., Kirkpatrick, B., Fisher, K., Nierenberg, K., Currier, R., & Wynne, T.T. (2009). Skill assessment for an operational algal bloom forecast system. *Journal of Marine Systems*, 151-161.

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