From Social Media to National Weather Service Products: Exploring New Outreach Tools for NOAA's Harmful Algal Bloom Operational Forecast System

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INTRODUCTION

Since it was transitioned from research to operations in 2004, NOAA's Harmful Algal Bloom Operational Forecast System (HAB-OFS) has provided year-round operational forecasts of the potential for *Karenia brevis* bloom formation at the coast, transport, intensification and associated respiratory irritation for the Gulf of Mexico region. Although the HAB-OFS has focused on maintaining high quality forecasts and refining the forecast system through research and development, the continued success of the HAB-OFS is also dependent on reaching its target audiences with useful information. The forecasts are communicated through two main products, the public conditions report and the technical HAB bulletin. These products are both intended as decision support tools: one for the general public and the other for a more technical audience that includes coastal resource managers, public health officials and researchers. After almost ten years in operations, it remains a challenge to sustain communication with current audiences, while attracting new interest. Beginning in August 2012, the HAB-OFS team launched a coordinated outreach strategy with the goal of increasing awareness of the HAB-OFS program and its products among potential HAB bulletin users and the general public.

METHODS

Goal

To reach more people with important public health information by increasing the number of people that use HAB-OFS products:

- Increasing subscriptions to the bulletin.
- Increasing views of the public conditions report.

Metrics Used for Assessment

1. Increase bulletin subscribers by 20% over FY12.
2. Increase requests for bulletin subscription and other information by 25% over FY12.
3. Increase # of website visits per year by 25% over FY12.

Outreach Tools (see Table 1)

Table 1. Descriptions of the three outreach tools implemented by the HAB-OFS team in FY12 & FY13.

OUTREACH TOOL	DESCRIPTION/PURPOSE	UPDATE FREQUENCY	TARGET AUDIENCE	LAUNCH DATE
Newsletter	• Provides updates on HAB-OFS activities and new product developments. • Answers frequently asked questions and gives additional product background.	Quarterly	Bulletin subscribers	FY12 Q4 8/8/12
NOAA HAB (Red Tide) Watch Facebook Page	• Disseminate public conditions reports. • Network with HAB-OFS partners. • Share news and inspire public interest in HABs.	2 to 5x per week	Public	FY12 Q4 9/7/12
National Weather Service (NWS) Beach Hazards Statement	• Criteria-based product, disseminated by NOAA's NWS for a variety of coastal hazards. • Disseminated when "high" levels of respiratory irritation are forecasted by the NOAA HAB-OFS.	As needed, daily	Public (only in Tampa Bay WFO)	FY13 Q2 2/4/13

MORE ABOUT THE BEACH HAZARDS STATEMENT

Since June 2012, NOAA's National Weather Service (NWS) has been testing public alerts for coastal hazards such as rip currents. Following user meetings and coordination with HAB-OFS Florida partners, in February of 2013, the NWS Tampa Bay weather forecast office (WFO) began issuing alerts for HABs when the HAB-OFS forecasted a potential for high levels of respiratory irritation from Levy County south to Lee County. The alerts are issued to the public via weather.gov, NOAA Weather Radio and other NWS systems. The messages include HAB-OFS forecasts and links to more information from NOAA and HAB-OFS Florida partners.

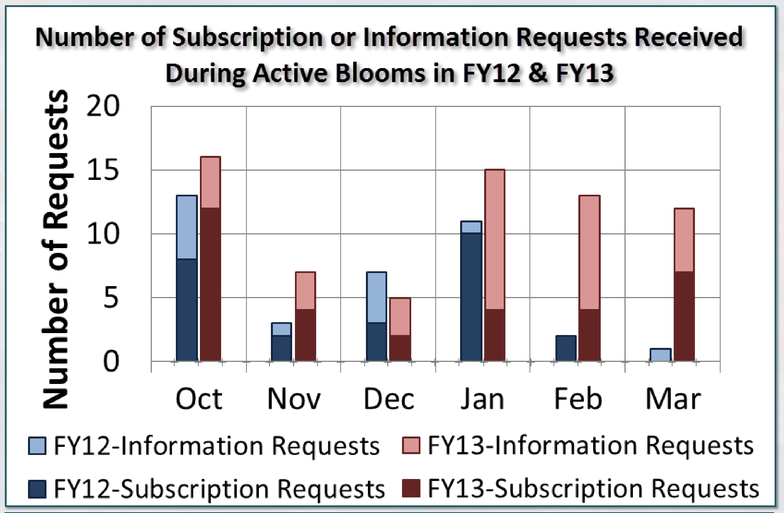

Figure 1. Number of subscription or general information requests received by the HAB-OFS team during active blooms in FY12, before the outreach tools were implemented, and FY13, after the outreach tools began to be used.

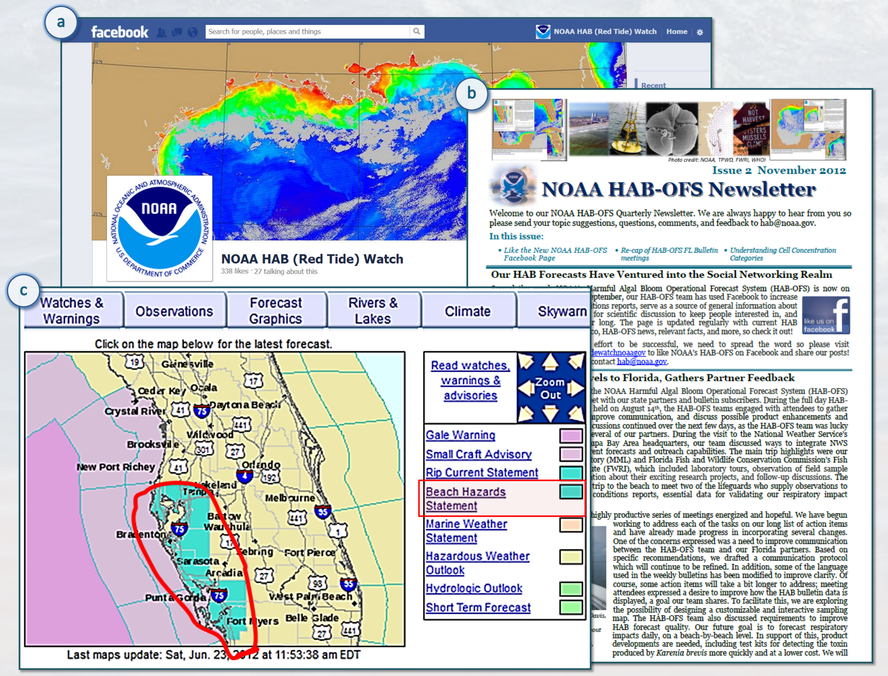

Figure 2. Examples of the three HAB-OFS outreach tools (*clockwise from top*):

a) NOAA HAB (Red Tide) Watch Facebook Page: https://www.facebook.com/Habredtidewatchnoaagov

b) NOAA HAB-OFS Newsletter: http://tidesandcurrents.noaa.gov/hab/newsupdates.html

c) NOAA National Weather Service Beach Hazards Statement: http://www.nws.noaa.gov/beachhazards

Acknowledgements

Special thanks to NOAA's CO-OPS (especially HAB analysts), National Centers for Coastal Ocean Science and National Weather Service.

The development and implementation of these outreach tools , especially the NWS Beach Hazards Statements, was dependent on cooperative efforts and extensive input from our external partners. Many thanks to the following agencies: Florida Fish and Wildlife Conservation Commission Fish and Wildlife Research Institute, Mote Marine Laboratory and Florida Department of Health.

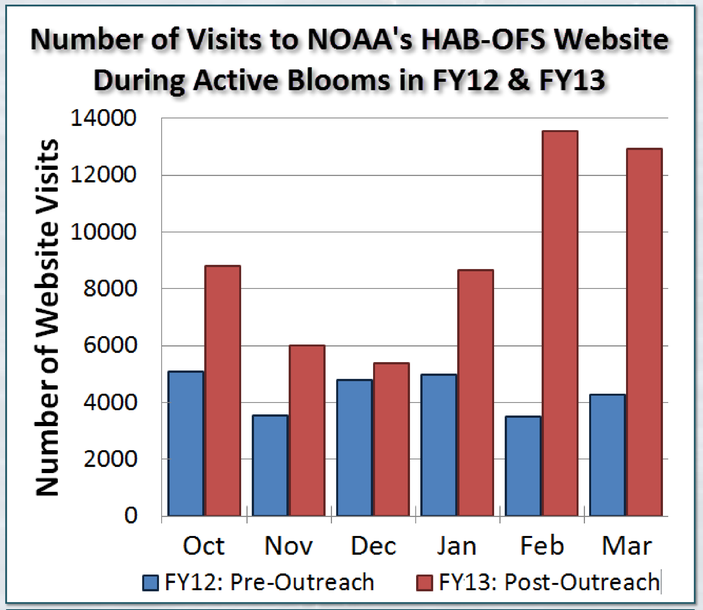

Figure 3. Number of visits to NOAA's HAB-OFS website during active blooms in FY12, before the outreach tools were implemented, and FY13, after outreach tools began to be used. The newsletter and Facebook page were launched on Aug. 8 and Sep. 7 of FY12, while the NWS Beach Hazards Statements were launched on Feb. 4 of FY13.

RESULTS & DISCUSSION

Requests for HAB Information Increased Dramatically in FY13

- In FY13, inquiries from bulletin subscribers and the public increased by 182% over FY12 levels.
- Throughout FY13, there were more information requests than in FY12, indicating that outreach tools such as the HAB-OFS newsletter and the Facebook page may be successful methods for encouraging dialogue with the public.

Number of Visits to the HAB-OFS Website Increased, Especially While Beach Hazards Statements were Released

- In FY13, the number of visits to the HAB-OFS website increased by 29.7% over FY12 levels. Since there were blooms present in Florida and Texas in both FY12 and FY13 for similar amounts of time, this is unlikely to be due solely to bloom activity.
- During the release of the Beach Hazards Statements in February and March of FY13, website visits increased by 202-284% over FY12 levels.

Bulletin Subscription Requests Increased While Beach Hazards Statements were Released

- During the release of the Beach Hazards Statements in February and March of FY13, requests increased 100-600% over FY12 levels.
- However, bulletin subscription requests did not increase in FY13 overall. In fact, they were 16.3% lower than FY12 levels, indicating that the Facebook page alone did not lead to subscription requests.

CONCLUSION

The Outreach tools utilized in FY13 successfully increased visits to the HAB-OFS website and the use of the public conditions reports. In fact, the NOAA Facebook page has followers not only from the Gulf of Mexico region, but from around the world. Although these tools alone did not increase requests for bulletin subscription, they did encourage a dialogue among users, which continued throughout the year, even when a bloom was not present. This increased feedback is valuable for improving the HAB-OFS products. Additional methods for increasing bulletin subscription may be explored in the future. NOAA is currently working to address lessons learned from the first HAB Beach Hazards Statement test period, with the goal of expanding the statements beyond the Tampa Bay Weather Forecast Office (WFO) to WFO's in other parts of Florida and Texas.

Assessment of the Eastern Gulf of Mexico Harmful Algal Bloom Operational Forecast System: A Comparative Analysis of Forecast Skill and Utilization from 2004 to 2012

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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[1,2]. 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. From May 1, 2004 to April 30, 2012, 697 total forecasts were issued for the eastern GOMX resulting in a total of 1623 bloom days spanning 17 confirmed HAB events[2]. 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, Respiratory Impacts, and Potential for Bloom Formation associated with the bloom. See Table 1 for descriptions.

Assessment

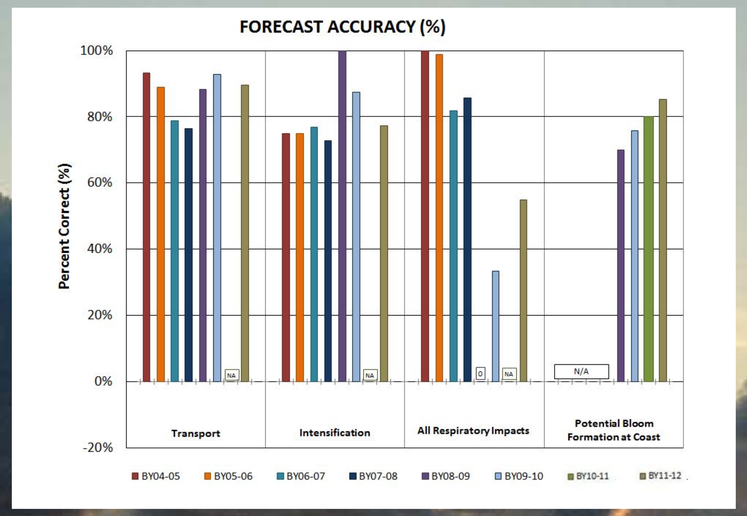
- Forecasts were evaluated for accuracy and usability each week based on the following post-bulletin data.
  - Bulletin Utilization: Media or public health reports, sampling response, written/ telephone responses or inquiries, etc.
  - Transport and Intensification: Satellite imagery and/or *in situ* sample data.
  - Respiratory Impacts: Observations of slight to high respiratory irritation within the forecast area (county) as reported by state agencies, lifeguards, research institutions, and the public.
- Assessment data was grouped by bloom year (BY), e.g. May 1 YYYY to April 30, YYYY.
- Some assessment data is subjective and a lack of reporting confirming a forecast does not necessarily mean that forecast was inaccurate or the bulletin was not utilized.

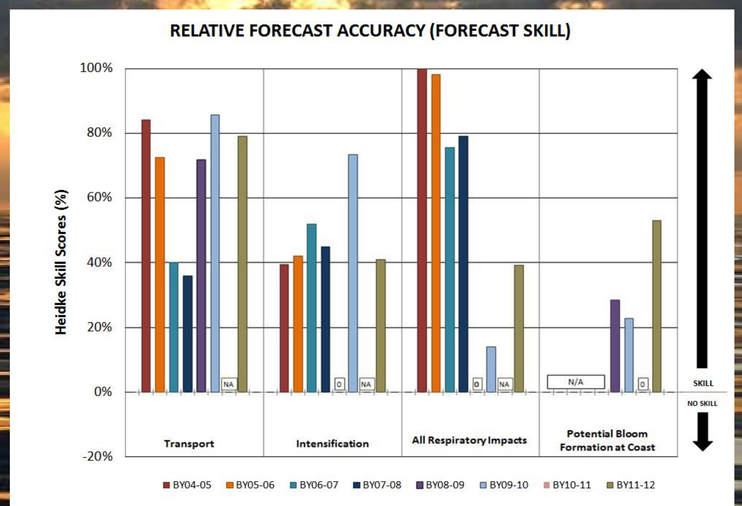
Statistical Analysis

- Assessability- % of forecasts with sufficient evidence to be adequately evaluated
- 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. This is reported as a range between -100% and 100%, with a score over 0% indicating improvement over random chance at predicting an event[3].
- Bulletin Utilization- reported as % where at least one bulletin was utilized per week

Forecast Component	Definition	Forecast	Data Used
Transport	Direction bloom is likely to migrate	• North • South • No Change	• NWS forecasted winds • Ekman Transport
Intensification	Expected change in bloom concentration	• Increase • Decrease • No Change	• NWS forecasted winds • K. brevis samples • MODIS AQUA imagery
Respiratory Impacts	Potential level of respiratory impacts caused by bloom	• None • Very low • Low • Moderate • High	• NWS forecasted winds • K. brevis samples • MODIS AQUA imagery
Potential for Bloom Formation at the Coast	A forecast of conditions that are favorable for bloom formation	• Favorable • Unfavorable	• NWS forecasted winds • Ekman Transport

Table 1: Definitions of forecast components for the Florida region, the data required, and the selection for each component.





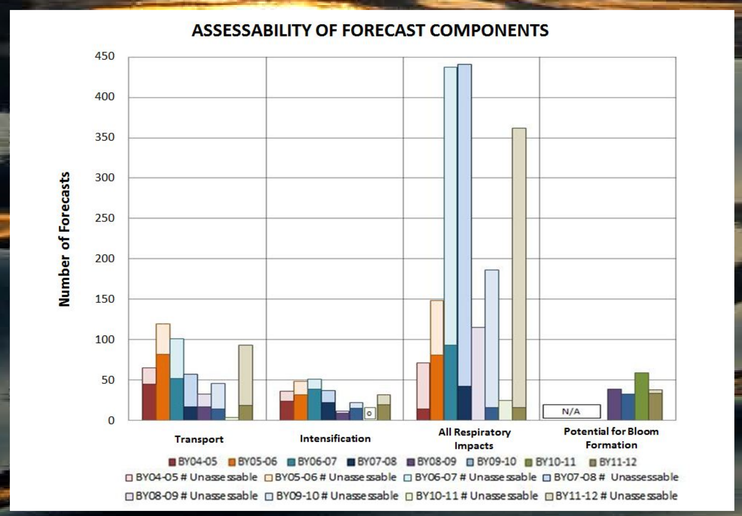


Figure 1. *(from top)* Percent correct forecasts (of total assessable), Heidke skill score (of assessable), and the assessability of forecast components.

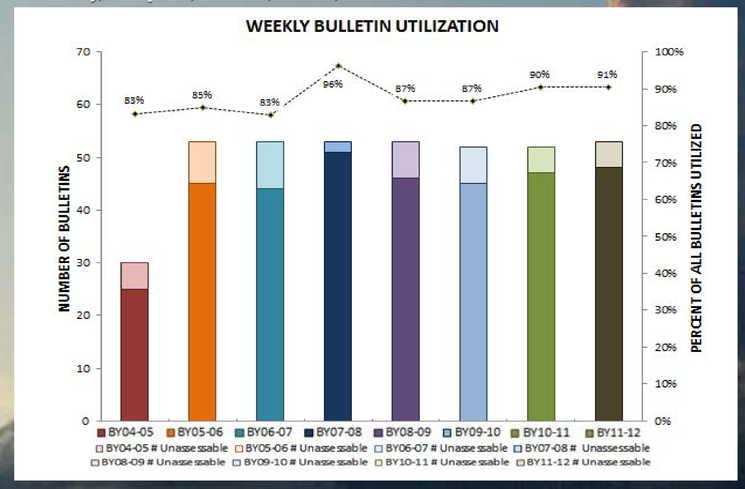


Figure 2. Bulletin utilization (percent) where at least one bulletin is utilized each week.

CONCLUSIONS

Greater User Feedback and Information is Required to Assess Forecast Accuracy and Bulletin Utilization

- Respiratory Impact Forecasts have the lowest confirmation percentage and require the greatest amount of information from users and the public to assess.
- BY05-06 respiratory forecasts were 54% assessable (greatest), while BY08-09 and BY10-11, where there was no bloom, both had 0% assessable forecasts.
- An average of 85% of respiratory irritation forecasts could not be confirmed per bloom year.
- Potential for Bloom Formation had the greatest percentage of assessable forecasts (99% average). These forecasts require a minimal amount of user feedback to assess and are primarily confirmed through MODIS AQUA imagery and *in situ* cell counts.

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 due to a general lack of impact reporting and because a report of "no impacts" cannot confirm the complete absence of impacts in a bloom region.
- Potential Bloom Formation at the Coast also had a high amount of skill (>20%) but the forecast is also subject to a number of false alarms. This may be attributed to the overall deficiency in understanding of specific factors that lead to bloom formation. Without knowing if a bloom has formed offshore or not, the forecast is restricted to predicting the potential for an unknown bloom that may have formed offshore to form at the coast based on physical oceanography.

Bulletins Successfully Assist Users

- Overall bulletin utilization where at least one bulletin was utilized per week was >87% each bloom season.
- In an effort to increase year-over-year bulletin utilization and further CO-OPS ability to address specific user needs, social media and outreach programs were initiated in BY12-13. These efforts will allow CO-OPS to incorporate a greater amount of feedback from a broader audience which will be used as guidance for improving HAB-OFS products moving forward.

Results Will Guide Future Forecasting and Skill Assessment

- The results of this comparative analysis will be used as guidance in improving the HAB-OFS program in the future. Using these results, operating procedures for each component will be analyzed in an effort to improve accuracy, assessability, and utilization.

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(1) 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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Acknowledgements

Special thanks to NOAA CO-OPS, especially HAB-OFS forecasters, National Centers for Coastal Ocean Science, and National Environmental Satellite Data Information Service CoastWatch Program, OrbImage Corporation, NASA

A sincere thank you is extended to the following partners who play a critical role in supporting the HAB-OFS: Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, Collier County Pollution Control and Prevention Dept., Mote Marine Laboratory, Alabama Dept. of Public Health

Assessment of the Western Gulf of Mexico Harmful Algal Bloom Operational Forecast System: Analysis of Forecasts & Utilization over the First Two Operational Years, 2010-2012

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Introduction

Blooms of the toxic dinoflagellate, *Karenia brevis*, occur nearly every year in coastal regions of the Gulf of Mexico (GOMX) causing impacts on public health, ecosystems, and regional economies. Following the successful transition of the eastern GOMX forecast system for harmful algal blooms (HABs) from research to operations along the Gulf coast of Florida in 2004, NOAA expanded its GOMX HAB Operational Forecast System (HAB-OFS) to include the coast of Texas (western Gulf of Mexico) in 2010. NOAA's GOMX HAB-OFS issues weekly bulletins that serve as decision support tools for coastal resource managers, federal and state agencies, and academic institutions. The Texas bulletins include three forecast components: bloom transport direction, transport distance and the daily potential for respiratory irritation along the coast. In order to continually improve the HAB-OFS, forecast skill and bulletin utilization are evaluated regularly. This analysis details the assessment of bulletin utilization and forecast skill for the first two years of operational status along the Texas coastline, encompassing 106 total bulletins issued for the western GOMX from October 2010 through April 2012. While there was no bloom along the Texas coastline during the first year of operations, 44 bulletins were issued during the 2011 Texas red tide, one of the longest lasting and largest blooms on record in Texas, covering the coastline and inshore bays and waterways from South Padre Island to the Galveston region. Results highlighted special challenges in the assessment of each forecast component and will be applied to improve HAB forecasting, product operations, and assessment for the western GOMX HAB-OFS.

Methods

Bulletin Forecasts

- Bulletin forecasts consisted of three components: **Transport Direction**, **Transport Distance**, and **Respiratory Impacts** produced by the bloom. See Table 1.

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 Direction and Distance:** Satellite imagery and/or *in situ* sample data, Texas General Land Office/Texas Automated Buoy System ROMS Current Model data and GNOME particle trajectory model results.
  - **Respiratory Impacts**: Observational data recorded and disseminated by state agencies, research institutions, and volunteer programs.
- Assessment data was then grouped by bloom year (BY), e.g. May 1, YYYY to April 30, YYYY.

Statistical Analysis[1,2]

- **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.

Table 1. Texas bulletin forecast component definitions.

FORECAST COMPONENT	DEFINITION	CATEGORIES	FORECAST BASIS
Transport Direction	Direction bloom is likely to migrate	• North • South • No Change	• Local ocean currents, TGLO/TABS ROMS Current Model • GNOME particle trajectory model
Transport Distance	Distance bloom is likely to migrate	• Rounded to nearest 10km	
Impacts	Potential respiratory irritation caused by the bloom *(forecast by region)*	• Very low • Low • Moderate • High • None	• Forecasted wind strength and direction • *K. brevis* concentration • Bloom proximity

Acknowledgements

Special thanks to NOAA CO-OPS, especially HAB analysts, National Centers for Coastal Ocean Science, and National Environmental Satellite Data Information Service CoastWatch Program, NASA. Forecasts and forecast assessment rely heavily upon the incredible efforts made to coordinate and collect field data. Many thanks to the following agencies: Texas Parks and Wildlife Department, Texas Department of State Health Services, Texas A&M University, Texas Sea Grant, Texas Red Tide Rangers.

Results

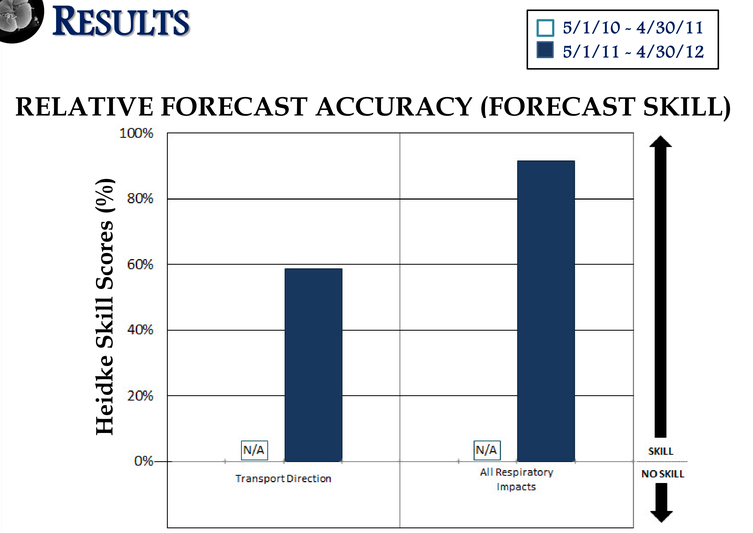


Figure 1. Heidke Skill Scores (of assessable) for transport & impact forecasts.

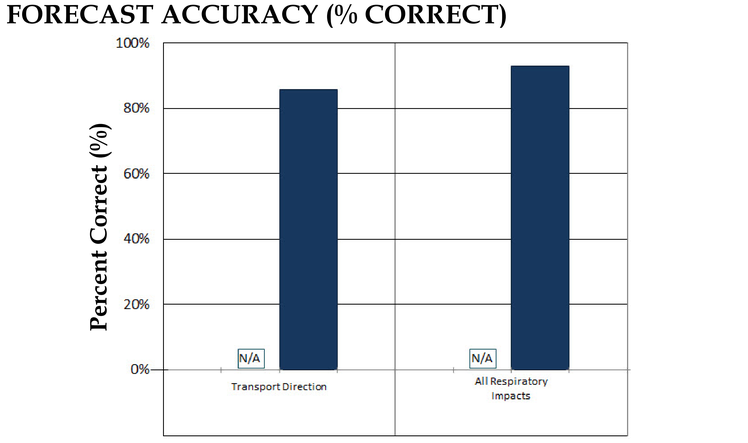


Figure 2. Percent correct(of assessable) for transport & impact forecasts.

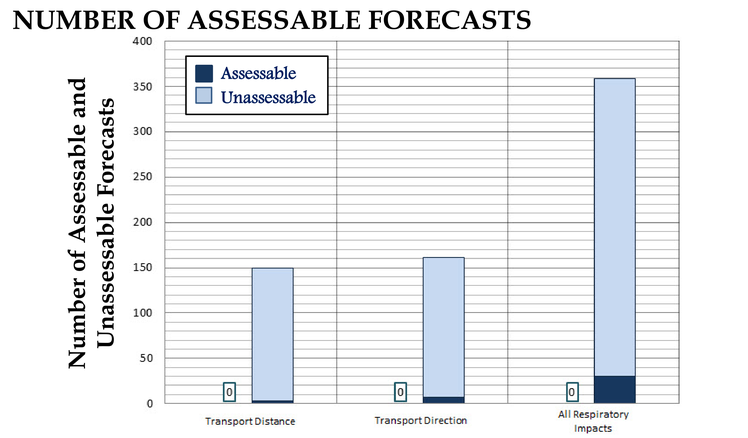
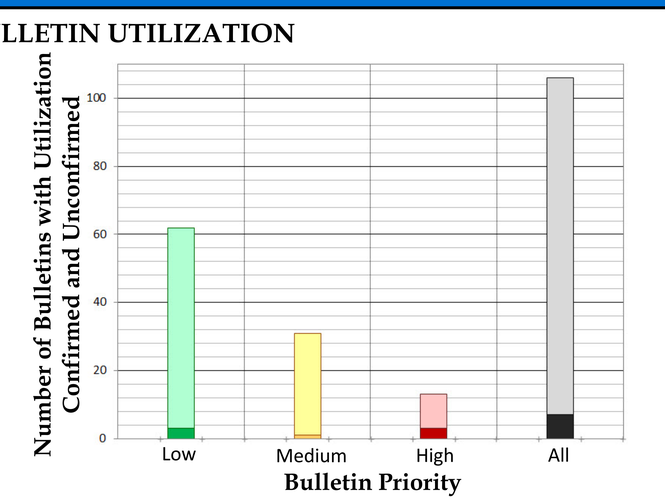


Figure 3. Number of assessable vs. unassessable forecasts.



Bulletin Priority Level				
Confirmed Bulletin Utilization	Low Priority	Medium Priority	High Priority	Total Bulletins
Unconfirmed Bulletin Utilization	Low Priority	Medium Priority	High Priority	Total Bulletins

Figure 4. Number of confirmed vs. unconfirmed bulletins, by priority level (low, medium, high, all), for BY10-12.

Conclusions

Bulletin components are forecasted with high accuracy and skill.

- Respiratory impact forecasts had the highest accuracy and skill (>90%).
- Transport forecasts also had a high amount of skill (>50%), but are the most difficult forecasts to assess. This will be addressed in the future.

More information is often needed to assess bulletin forecasts. Transport forecasts are the most difficult to confirm.

- <15% of all transport forecasts were assessable. Resuspended chlorophyll visible in the ocean color imagery along the Texas coastline makes it difficult to assess transport forecasts, which can be verified only using satellite imagery. While algorithms are already in place to remove much of the resuspension visible in western GOMX imagery, refinement of algorithms to remove more resuspension is necessary to better track feature and bloom initiation and transport.[3] Cloudy imagery during the bloom timeframe also limited analysis and assessment.
- <10% of all respiratory impact forecasts were assessable. Working with partners to address more systematic reporting of respiratory impacts and the use of social media for on-the-ground impact reports will help to confirm forecasts.

New methods to confirm bulletin utilization should be explored.

- <10% of all bulletins were confirmed utilized.
- Procedures to verify bulletin utilization via social media outlets should be explored. This, along with partner feedback, will help increase bulletin utilization confirmation.

Comparison of FL and TX forecasts over all operational active bloom years from BY04-12 reveals, on average:

- There were less assessable forecasts of all types in TX than FL.
- Transport forecast accuracy (% correct, of assessable) was similar (~85%) for TX and FL.
- Impact forecast accuracy and skill was greater in TX than the average scores for FL; however, TX had only one bloom during the assessment period and fewer assessable impact forecasts than FL on average.

References

[1]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.

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