

Economics of Harmful Algal Blooms

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Integrating Science, Policy, and Communications to Combat Harmful Algal Blooms

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HABs Avoided Damages Study

- Estimated net societal economic benefits associated with the deployment of the *Harmful Algal Bloom Interception, Treatment, and Transformation System* (HABITATS).
- Estimated the avoided damages from a cyanoHAB event and the value of potentially beneficial byproducts and compared to HABITATS costs.



[Societal Benefits of Cyanobacteria Harmful Algal Bloom Management in Lake Okeechobee in Florida](#)

HABs Avoided Damages Study

- Economic benefits analysis approach is cost effective and readily transferable.
- Study area: downstream of Lake Okeechobee in southeast Florida in the Saint Lucie and Caloosahatchee Rivers when water containing cyanoHABs was released from the lake.
- Retrospective analysis
- Compared benefits [avoided costs] to HABITATS costs.
- Many limiting factors to the analysis.
- Lower bound estimate of net benefits

HABITATS -- Algae Treatment and Transformation Workflow



Intercepting algae



Treating algae-laden water



Transforming algal biomass into biofuel

Shore-Based Rapid Air Flotation Technology (RAFT)

- Algae collected from the water surface with a floating weir skimmer and booms that focus the surface algae to the collection point.
- RAFT floats algae to surface
- Shore-based deployment



Dissolved Air Flotation + Oxidation (DAF)

- DAF lifts algae for removal
- Creates clean water that can be directly returned to the environment; concentrates the algal biomass to minimize the waste stream.
- Oxidation reduces toxicity and waste volume
- Modular and scalable



Hydrothermal Liquefaction

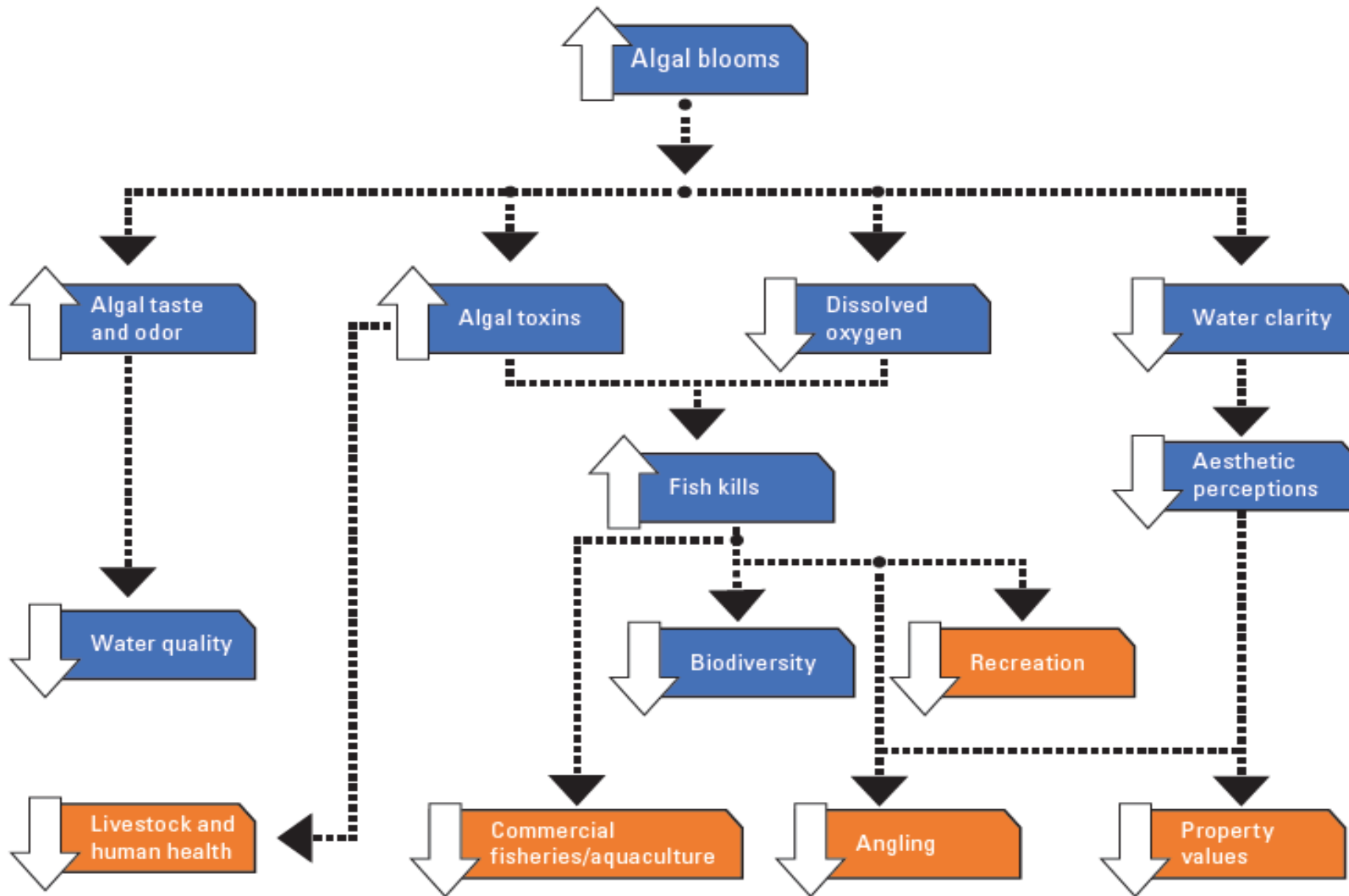
- Concentrated algal biomass waste stream transformed into biocrude fuel and fertilizer by hydrothermal liquefaction.



Benefits and Costs

- Benefits
 - Categories of benefits
 - Quantifiable and able to value in monetary terms
- Costs
 - Capital
 - Operating
- Ecosystem services framework
 - recreational fishing and boating
 - Aesthetics
 - water use
 - commercial fisheries and aquaculture
 - human health.





- Analysis focused on valuing the ecological damages connected to changes that occurred because of the 2018 cyanoHAB event. Estimating net benefits from the damages requires linking damages to lost ecosystem services and then estimating monetary values.
- Challenge: monetization of the impacts of excessive cyanobacteria growth on aquatic ecosystems
 - Inadequate scientific knowledge about the links b/t biophysical processes and outcomes for ecosystem services.
 - Existing damage because due to many other causes, including major changes in hydrology resulting from canal and land development.
- Benefit transfer approach. Uses existing data from other studies in a similar setting.
 - Best when applied to similar settings (which can be done on the basis of the availability of primary studies in the general study area) and when primary data are incorporated in tandem with the functional transfer (which can be done by integrating site-specific data as described in the following sections).
 - Estimates from this study should be considered a lower bound.

$$\text{Net Benefits of HABITATS} = (Q_s \times V_s \times E\%) + V_{ap} - (C_{ac} + C_{om})$$

Q_s = quantity of societal impacts,

V_s = value of societal impacts,

$E\%$ = % effectiveness of HABITATS,


V_{ap} = HABITATS ancillary product value,

C_{ac} = HABITATS amortized capital costs, and

C_{om} = HABITATS annual O&M costs

Recreation

- Pathway:
cyanobacteria die-off → reduced dissolved oxygen conditions → adverse effects on fish species → recreation impacts.
- A fish die-off can reduce commercial fishing stocks, decrease recreational fishing opportunities, and have further effects on biodiversity (e.g., predatory bird populations may suffer).
- Estimated economic value of foregone aquatic recreation (boating, fishing, swimming, etc.) during the 2018 cyanobacteria HABs outbreak: \$5.5 million.



Notice
An algae bloom has made
this area potentially
unsafe for water contact.
Avoid direct contact with
visible surface scum.

Aesthetics

- Proximity to water and the quality of that water can have a positive (or negative) effect on property values (i.e., HABs would be a disamenity and likely have a negative impact on property values).
- Analytic approach: hedonic property price analysis.

Distance - Value Relationship Associated with HABs



Aesthetics

- The extent that a HABs event might have additional impacts (for example, nuisance odor could increase impacts) or fewer impacts (for example, the perception of HABs not being an ongoing issue could reduce the impact) will affect the actual change in property value associated with a HABs event.
- The percentage change in property sales prices was estimated from the results of a hedonic property value study by Florida Realtors (2015). Those estimates are consistent with other hedonic study findings in the literature; for example, Bin and Czajkowski (2013) found the mean willingness to pay for water clarity is approximately 3.8 percent of the mean housing value in Martin County, Florida.
- To calculate the change in sales price, which represents lost value because of the 2018 HABs event on single-family property sales by county and by distance from the water, each property sale price was multiplied by the percentage change in property prices resulting from an additional foot of Secchi disk depth.
- The total estimate of property value-related economic losses in all four counties caused by the 2018 HABs event was about \$2.3 million, with most of the loss value accruing in Lee and Saint Lucie Counties.

Quantifying and Monetizing the Impacts on Water Use

- Assumed that the 2018 HABs event would not have affected the availability of drinking water and (or) affected water treatment protocols significantly [only a small proportion of treatment plants use surface water].
- HAB incidents can affect crop irrigation through diverse pathways. The decision to continue to use surface water for irrigation or to treat the water prior to irrigation will result in different potential impacts. An emerging body of evidence indicates that food crops are able to bioaccumulate cyanotoxins. This could result in consumer exposure and potential human health effects (Krimsky and others, 2019; Xiang and others, 2019).
- The use of surface water with HABs for livestock watering may result in impacts that include livestock mortality or morbidity resulting from HABs exposure. Although it is possible that there were societal impacts in terms of livestock mortality or morbidity, or both, the existing data were unable to distinguish and quantify those impacts.
- To quantify the potential impacts of HABs incidents on the agricultural use of water, the actual behavior of farmers and regulatory requirements in the region would need to be considered.
- Florida does not have guidelines restricting agricultural irrigation while cyanobacteria or cyanotoxins are in the water

Quantifying Impacts on Commercial Fisheries and Aquaculture

- Focused on commercial fisheries landings, freshwater commercial fishing licenses, and the location of aquaculture farms were analyzed.
- HABs could also have potential economic impacts on aquaculture in estuarine, nearshore marine, or freshwater environments, even though aquaculture was not widespread in impacted area.
- Data did not clearly indicate that the 2018 HAB event had an adverse economic impact on aquaculture around the Caloosahatchee River and downstream estuary. Even in cases where landing volumes decreased in 2018, there was not enough evidence to attribute reduced landing volumes to HABs (natural variation and weather patterns, among other exogenous factors, all influence annual and long-term landings).
- It is possible that HAB outbreaks could alter food web dynamics and cause nonlethal population effects resulting in reduced harvests in later years but not clear if there is any link between landing volumes and the 2018 event. Natural variation, weather patterns, and other external factors could all influence annual and longer-term landings.

Quantifying Impacts on Human Health

- Impacts would be associated with exposure that may have occurred during recreation.
- Available data insufficient to quantify the economic costs of impacts.
- In Florida, most data are from self-reported exposures and illnesses, which gives rise to several challenges when quantifying human health impacts.



**WATER CONTACT
HEALTH ADVISORY**

 **AVOID WATER
CONTACT**

 **EVITE CONTACTO
CON EL AGUA**

High Levels of blue-green algae have been detected that can produce harmful toxins.

- Do not allow pets to swim/drink the water.
- Do not come in contact with reservoir water, if so rinse with drinking water.

Details visit wsscwater.com/HAB

 **301-206-7011**



Metric	Scenario	
	Reference case - w/satellite data	Counterfactual - no satellite data
Time until advisory posting (days)	0	7
Number of people exposed to cyanoHAB	0	8,000
Number of people who experience symptoms	0	200 experience mild symptoms 170 experience moderate symptoms 30 experience severe symptoms
Cost per case (\$2017)	Mild: \$11 Moderate: \$264 Severe: \$10,719	Mild: \$11 Moderate: \$264 Severe: \$10,719
Total estimated cost due to health outcomes (\$2017)	0	370,000

Source: Stoming, S. et. al., *GeoHealth*, Quantifying the Human Health Benefits of Using Satellite Information to detect Cyanobacterial Harmful Algal Blooms and Manage Recreational Advisories in U.S. Lakes, June 18, 2020

Estimates of the avoided costs associated with using HABITATS to mitigate HABs Impacts

- Total estimated economic losses:
 - Aesthetics (property values) - \$2.3 million
 - Aquatic recreation - \$5.5 million
- Note: values are for a single 3-month event for the downstream impacts in the Caloosahatchee and Saint Lucie Rivers
- Should be considered as a lower bound because certain categories of impacts are not currently quantifiable.

- In terms of assessing effectiveness of HABITATS in reducing HABs, one of the most critical parameters is the algal depth-dilution coefficient (DDC).

HABITATS – Estimated capital and operating costs

- Capital expenditures are costs incurred associated with the production of the equipment and are considered “one-time.” Capital expenditures include:
 - Weir skimmers, booms, the dissolved air flotation, ozone (O₃), screw press, anaerobic membrane bioreactor, hydrothermal liquefaction equipment, and peripherals (hoses, tanks, gravel, fittings).
 - Capital expenditures were amortized for the design life of the equipment. A 20-year design life for all equipment and a 5-percent discount rate were assumed.
- O&M expenditures are ongoing costs and vary with the duration of use. O&M costs included:
 - Labor, chemicals, equipment maintenance, deployment, and energy costs.
 - Assumed that HABITATS is deployed for a 90-day period with a 1-week setup and tear down, with the equipment operating at 24 hours per day.
- Cost analysis relied on information from the Corps of Engineers pilot studies and assumptions for the duration of deployment, based on the actual 2018 HAB event in Lake Okeechobee, Florida.
- The HAB event lasted for 3 months and the study assumed that HABITATS would be required for the entire duration.
- Note: Capital and O&M costs can vary with time and across space because of the variable components of the total costs, which depend on several factors, including the algal dispersion in the water column, the amount of water to be treated, and the time required for the HABITATS deployment. In addition, the scalability of the HABITATS process might lead to cost reductions because of economies of scale if the frequency of equipment usage increased as more HABITATS modules were deployed

Estimated HABITATS Operating Costs

Estimated Total HABITATS Costs (capital and O&M costs; \$ millions)

River	Low Depth Dilution Coefficient scenario [algae distributed throughout the water column]		High Depth Dilution Coefficient scenario [most algae concentrated close to surface]	
	HABITATS (DDC = 0.25)	HABITATS+RAFT (DDC = 1.4)	HABITATS (DDC = 2)	HABITATS+RAFT (DDC = 3)
Caloosahatchee R	3.12	5.02	5.51	5.95
Saint Lucie R.	1.44	2.09	2.26	2.41
Total	4.56	7.11	7.77	8.36

\$ millions per day

River				
Caloosahatchee R	0.035	0.056	0.061	0.066
Saint Lucie R.	0.016	0.023	0.025	0.027
Total	0.051	0.079	0.086	0.093

Summary -- Net benefits

	Net Benefits (\$millions)			
	Low DDC scenario [algae distributed throughout the water column]		High DDC scenario [most algae concentrated close to surface]	
	HABITATS (DDC = 0.25)	HABITATS + Rapid Air Flotation Technology (DDC = 1.4)	HABITATS (DDC = 2)	HABITATS+Rapid Air Flotation Technology (DDC = 3)
Benefits/avoided costs [property value effects + recreation effects; water use, commercial fishing, health effects not quantified or valued]	1.83	5.14	5.97	6.8
Ancillary product benefits	0.61	1.8	2.11	2.39
Total costs	4.56	7.11	7.77	8.39
Net benefits	-2.12	-0.17	0.31	0.8

Finally...

- Key to being able to do economic analysis is estimating benefits (or avoided costs)
- Mitigation – probably need to look at the cost effectiveness of variety of approaches. Not just water treatment...
- No easy way around data issues – Need data! Especially baseline data on ecosystem services!
- Benefits transfer is reasonable approach and very feasible.
- A good place to start – do a study to estimate econ benefits of recreation