Assessing the Economic Benefit of the Next-Generation Geostationary Satellite Hyperspectral Ocean Color Instrument: The Geostationary Extended Observations (GeoXO) OCX

David G. Lubar, Sr. Project Leader, The Aerospace Corporation &

Tracy Rouleau, President, TBD Economics, LLC ;

Co-Authors: Michael L. Jamilkowski, Sr. Project Scientist, The Aerospace Corporation, and

Jeffery Adkins, Senior Economist, TBD Economics, LLC

January 13, 2025

Presented at the AMS 2025 Annual Meeting, New Orleans, LA *OTR2024-01220*

© The Aerospace Corporation, 2025

Outline

- What is GeoXO?
- Why this is important to end users of ocean color products
- GeoXO improved capabilities
- Applications of GeoXO Ocean Color Instrument (OCX) observations
- Economic Analysis & Preliminary Results
- Q&A

What is GeoXO?

- Geostationary Extended Observations (GeoXO) – the next generation Geostationary earth-observation system
- Will replace the current Geostationary Operational Environment Satellite (GOES) R-Series system, in approx. 2032
- GeoXO is planned as a three-satellite constellation: GeoXO-West, GeoXO-Central and GeoXO-East
- GeoXO will carry several instruments similar to GOES-R: Vis/IR Imager (GXI) & Lightning Mapper (LMX)
- GeoXO is planned to carry several new instruments: Hyperspectral IR Sounder (GXS), Atmospheric Composition (ACX), and Ocean Color (OCX)
- This presentation focuses on the OCX instrument

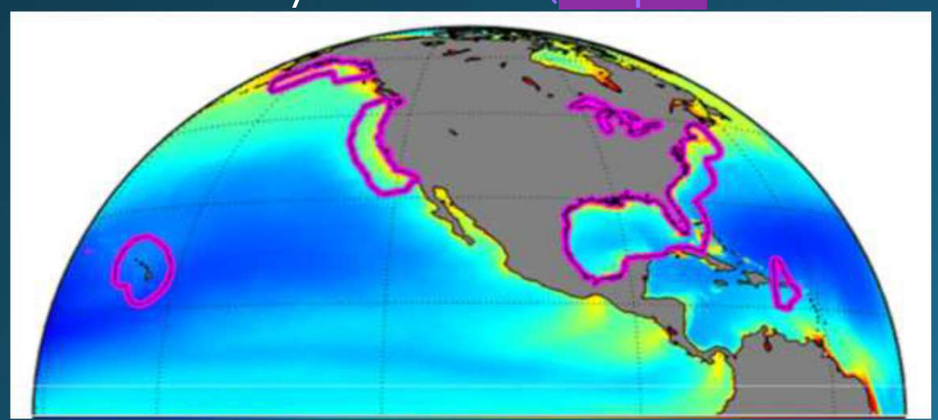


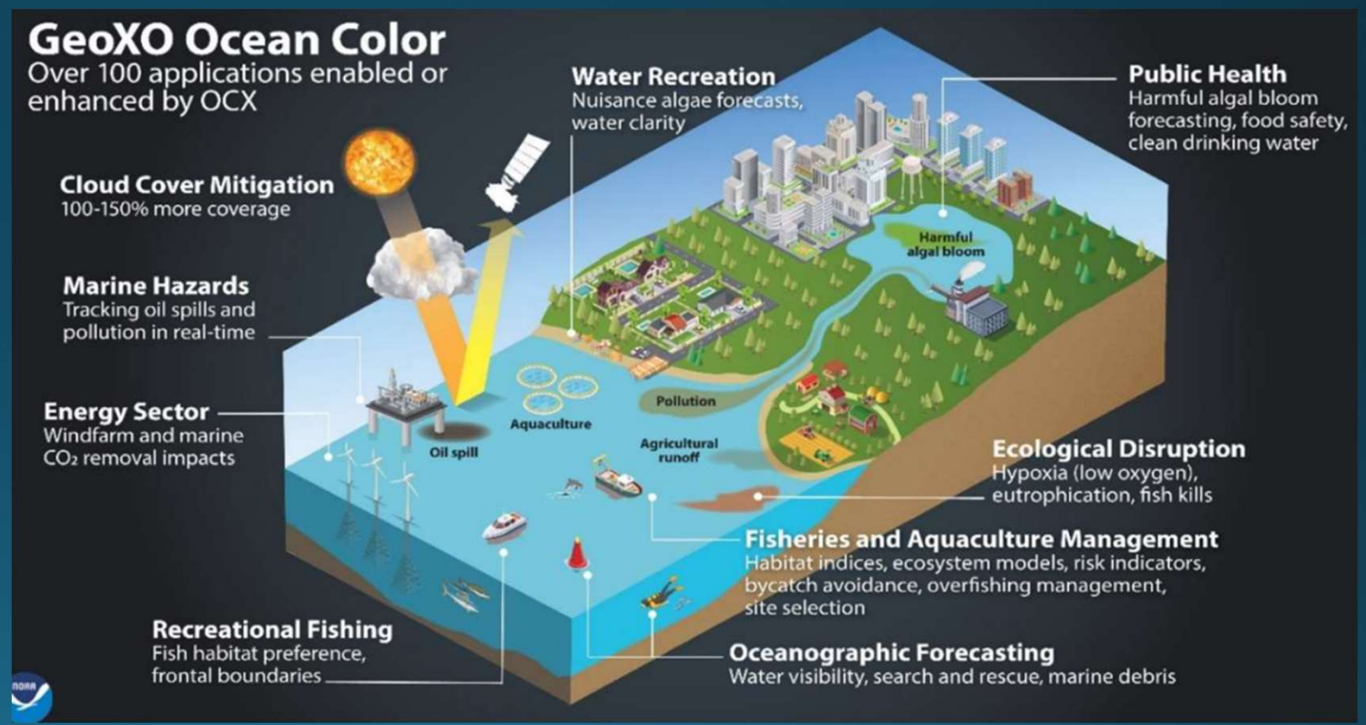


All Images from: https://www.nesdis.noaa.gov/our-satellites/future-programs/geoxo/geoxo-spacecraft-instruments

Why are Ocean Color products important to end users?

- "The marine economy contributed a total of $476 billion in ($ US) economic impact in 2022, making up nearly 2% of the U.S. gross domestic product (GDP)"[1]
- Having accurate and up-to-date ocean color (OC) products are vital to many parts of the Blue Economy
- OCX will observe ocean: biology, chemistry, and ecology to assess ocean productivity, ecosystem change, coastal and inland water quality, seafood safety, and hazards like harmful algal blooms (HABs)
- OCX will collect ocean data within the U.S. Exclusive Economic Zone (EEZ) and Great Lakes every two hours (Purple zones below)





[1] NOAA News, June 6, 2024, https://www.noaa.gov/news-release/us-marine-economy-continues-upward-trend#:~:text=The%20marine%20economy%20contributed%20a,gross%20domestic%20product%20(GDP).

Improved capabilities of GeoXO OCX

- GeoXO OCX has many vital, improved capabilities over current space-based Ocean Color Instruments
- Most current OC products are derived from low-earth-orbiting (LEO) environmental satellite instruments data, such as the NOAA JPSS VIIRS & NASA Aqua & Terra MODIS instruments:
  - The primary shortcoming of data from these LEO OC instruments is that they only can provide a refresh rate of once per day
  - So, if there are any masking clouds, sun glint, or other blocking phenomena, those data are unavailable and the derived products suffer from lengthy data lags
  - This also limits the ability to capture diurnal variability as is common with harmful algal blooms (HABs)
- The OCX data refresh rate of every two hours will significantly minimize ocean cloud masking and other obscuration phenomena in the U.S. Exclusive Economic Zones (EEZs)
- Furthermore, most current LEO OC instruments are limited to a multispectral capability, whereas the GeoXO OCX will have a hyperspectral capability
- For example, the approx. number of channels in the JPSS multispectral VIIRS sensor is 20-30 versus GeoXO OCX's hyperspectral ~350 channels

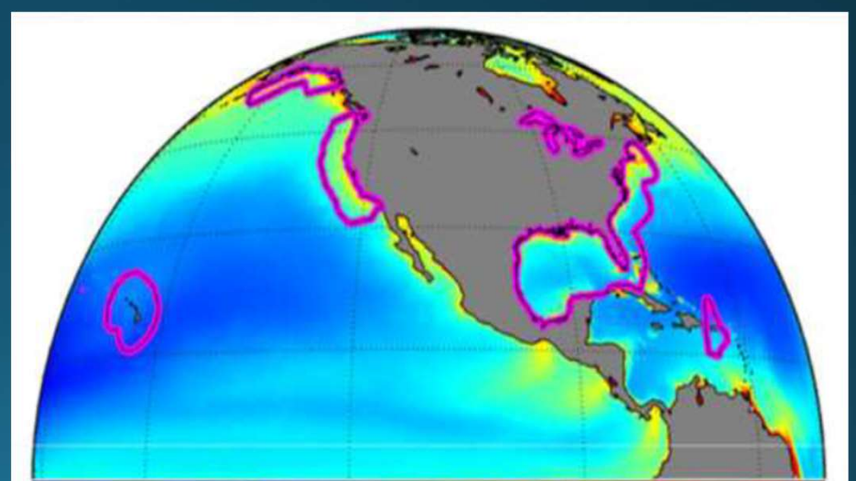


Image Source: https://journals.ametsoc.org/view/journals/bams/105/3/BAMS-D-23-0048.1.xml)

GeoXO OCX Capabilities Compared to Other Space-Based Ocean Color Instruments

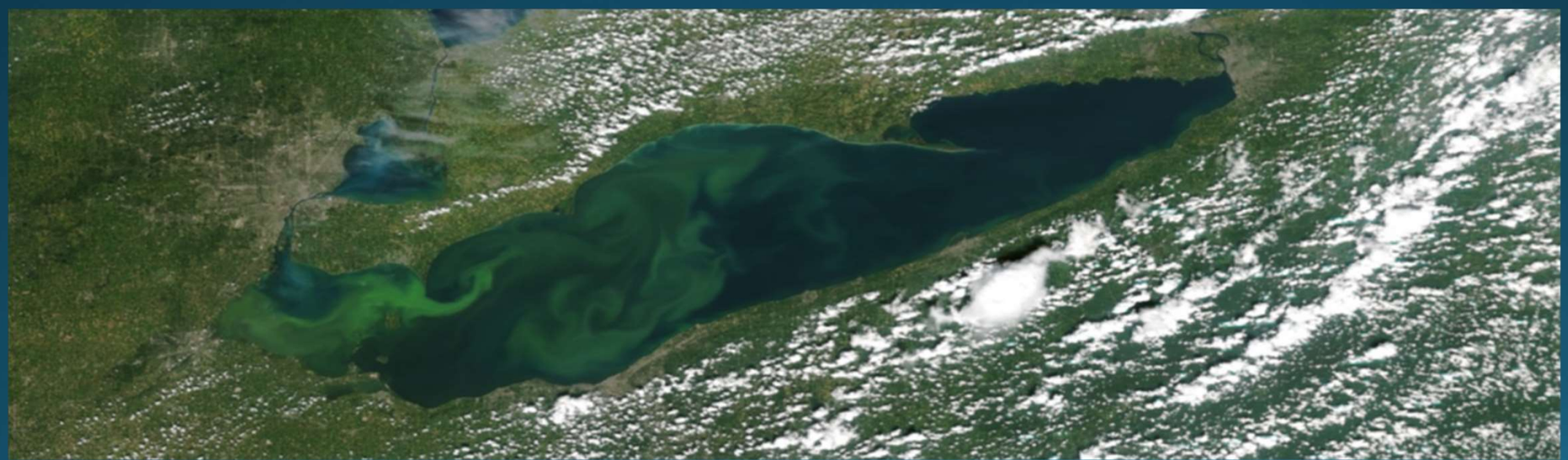
Sensor	Operational/Research	Orbit	Multi-Spectral/ Hyperspectral	Refresh Rate	Spatial Resolution	Spectral Bands
Sentinel OLCI	Operational	LEO	MS	2-3 days	300 m	21
Landsat OLI	Operational	LEO	MS	16 days	15/30 m	VNIR, SWIR
Aqua + Terra MODIS	Research/Operational	LEO	MS	1-2 days	250/500/1,000 m	36
JPSS VIIRS	Operational	LEO	MS	1-2 days	750 m	22
PACE OCI	Research 2024-26	LEO	HS	1-2 days	1,000 m	SWIR-UV
GLIMR	Research 2027-28 (TBD)	GEO	HS	2-6x per day	535 m	340 – 1040 nm
COMS GOCI	Operational	GEO	MS	1 per hour	500 m	8 channels VIS/NIR (412-865 nm)
GEO-KOMPSAT-2B GOCI-II	Operational	GEO	MS	1 per ½ hour	250 m	13 channels UV, VIS & NIR (380 - 865 nm, 10-40 nm bandwidth)
GeoXO OCX	Operational starting 2032	GEO	HS	6x per day	390 m	350 – 1020 nm

Highest Utility Higher Utility Usable (Ref: Gathered from various, multiple sources)

Table 1: Capabilities comparisons of various current and future space-based ocean color instruments (Source: The authors, from various, multiple sources).

Applications of GeoXO OCX observations

- Harmful algal blooms
- Hypoxia
- Fisheries models and management
- Sediment loading and turbidity
- Cyclonic eddies



https://www.nesdis.noaa.gov/news/geoxos-ocx-instrument-will-be-game-changer-satellite-ocean-observations

Economic Analysis



TBD Economics, LLC

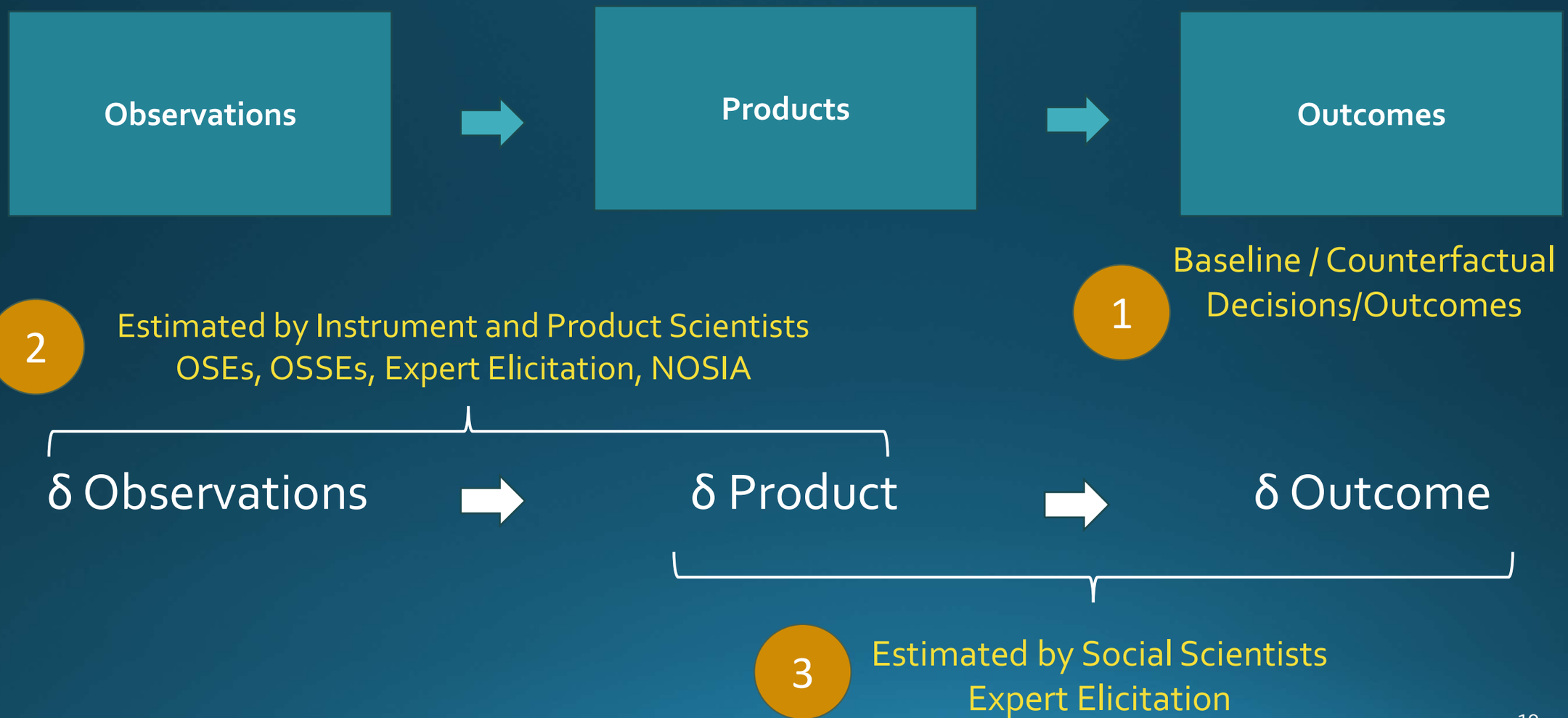
https://www.freepik.com/

The Value of Information

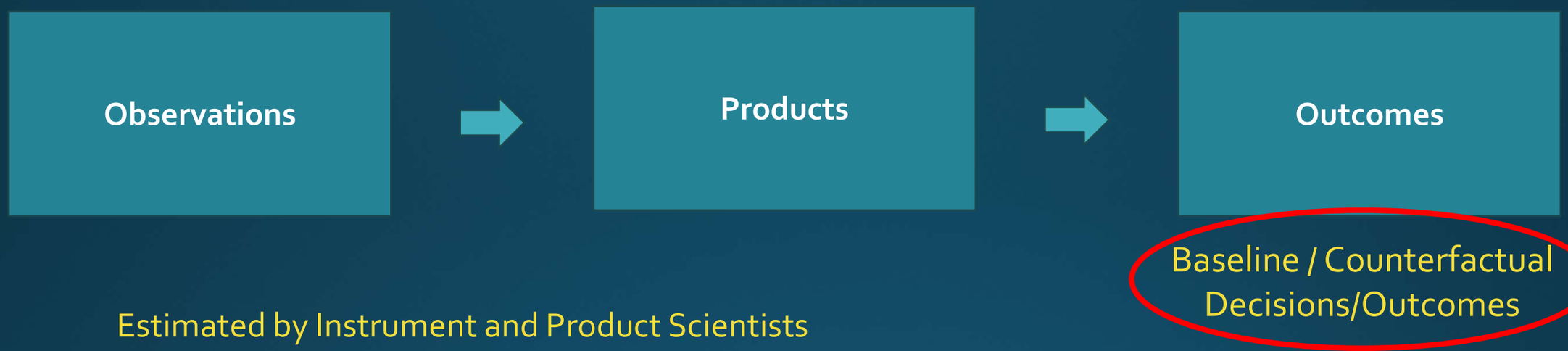
"…forecasts possess no intrinsic value. They acquire value through their ability to influence the decisions made by users of the forecasts."[2]

[2]Murphy, A.H., 1993. What is a good forecast? An essay on the nature of goodness in weather forecasting. Weather and Forecasting, 8(2), pp.281-293.

Value Chains and Data Requirements



Key Data Requirements

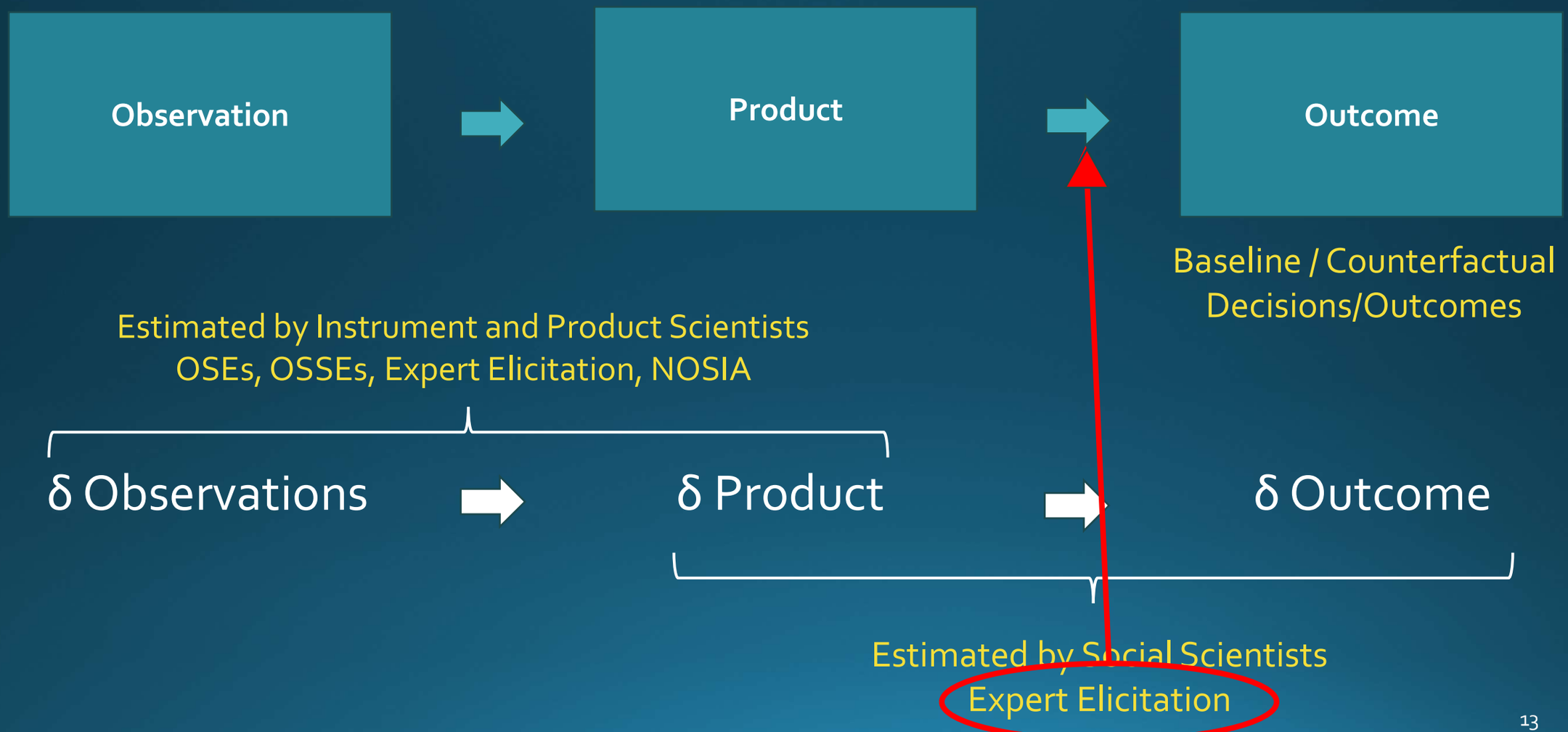


Estimating the average annual impacts of HABs

- Literature review, 209 studies
- Model to extrapolate study findings to all historical HABs
- GIS-based analysis[3] to show distribution of impacts

[3] A geographic information system (GIS) is a system that creates, manages, analyzes, and maps all types of data. GIS connects data to a map, integrating location data (where things are) with all types of descriptive information (what things are like there). This provides a foundation for mapping and analysis that is used in science and almost every industry. GIS helps users understand patterns, relationships, and geographic context. The benefits include improved communication and efficiency as well as better management and decision making (https://www.esri.com/en-us/what-is-gis/overview#:~:text=A%20geographic%20information%20system%20(GIS,what%20things%20are%20like%20there).

Key Data Requirements



Expert Elicitation Process

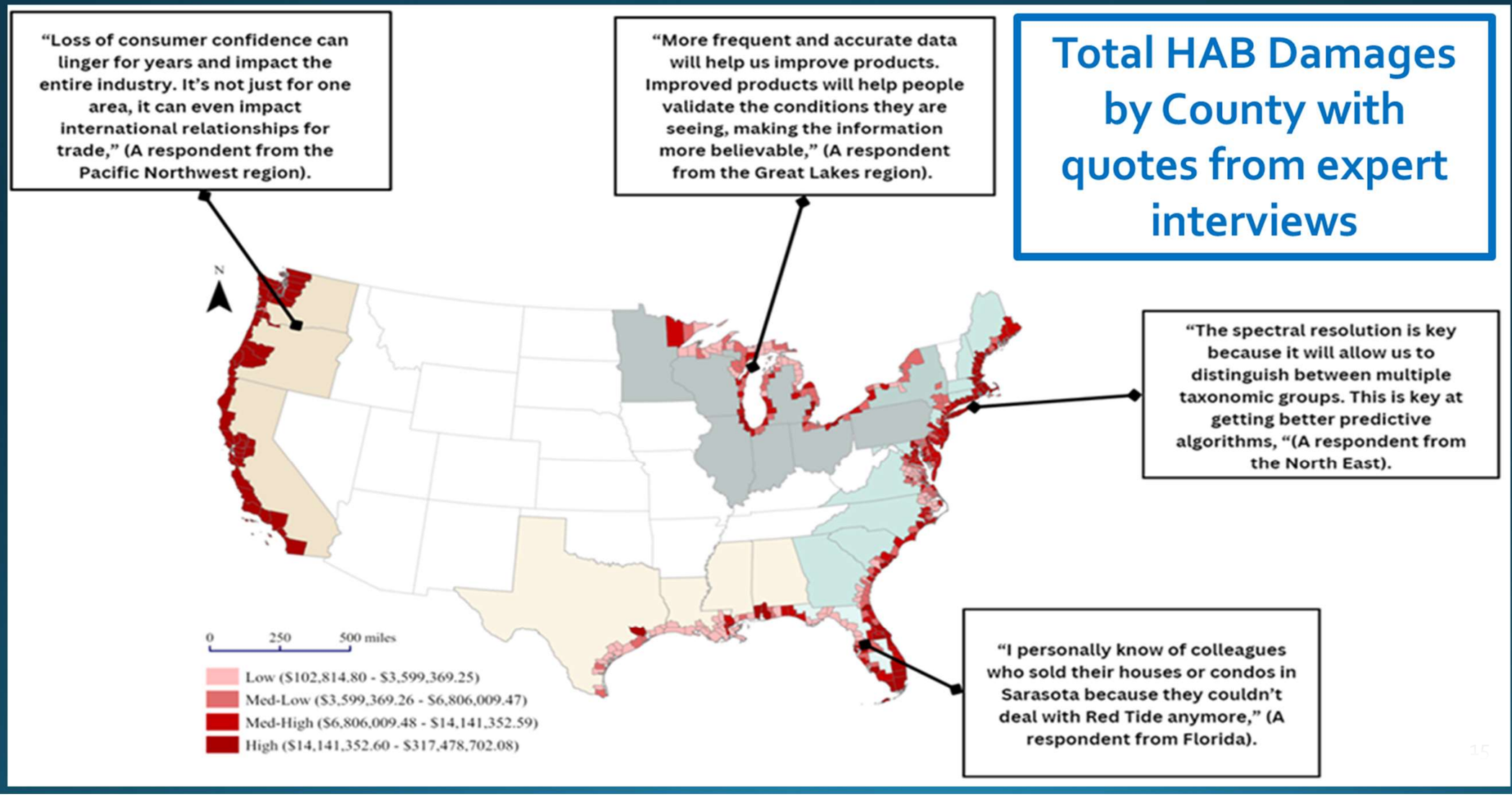
- 50 interviews with subject matter experts
- 13 Semi-structured interviews





Images: TBD Economics, LLC

How do GeoXO OCX-enhanced products improve outcomes?



Bottom-line: HAB-related benefits of GeoXO OCX, 2032 -2055 (in $2023)

Total Present Value of Benefits from 2032 – 2055 at 3.1% Discount Rate ($1,000)			
	Unweighted	Weighted	Weighted with Tourism Adjustment
Minimum	$763,405	$2,143,254	$2,143,254
Mean	$2,936,037	$3,454,049	$2,590,651
Maximum	$6,870,604	$5,048,246	$3,171,310

- Greater than the incremental cost of adding ocean color sensor to GeoXO satellites
- Total present value, GeoXO OC sensor: ~$700 million (GeoXO Benefit Analysis, 2022)

Q&A: Questions?

Additional/Backup Slides

Preliminary Findings: Average annual impacts of HABs (in $2023)

Total estimated expected annual damages ($1,000)

	Commercial Fishing	Recreational Fishing	Tourism	Health	Total
West	67,255	46,168	104,619	22,144	240,188
East	27,437	5,232	2,375	24,659	59,704
Gulf	17,763	100,928	221,438	17,681	357,811
Great Lakes	109,356	126,664	226,437	8,231	470,690
Total	221,812	278,994	554,871	72,716	1,128,394

Preliminary Findings: Benefits of GeoXO OCX, reduction of HAB impacts (in $2023)

Expertise weighted total estimated expected annual damage reductions with 5% tourism reductions ($1,000)

	Commercial Fishing	Recreational Fishing	Tourism	Health	Total
Minimum %	25.0%	25.0%	5.0%	7.5%	
Mean %	27.5%	33.3%	5.0%	13.5%	
Maximum %	30.0%	45.0%	5.0%	20.0%	
Minimum Value	55,453	69,749	27,744	5,454	158,399
Mean Value	60,998	92,905	27,744	9,817	191,464
Maximum Value	66,544	125,547	27,744	14,543	234,378