

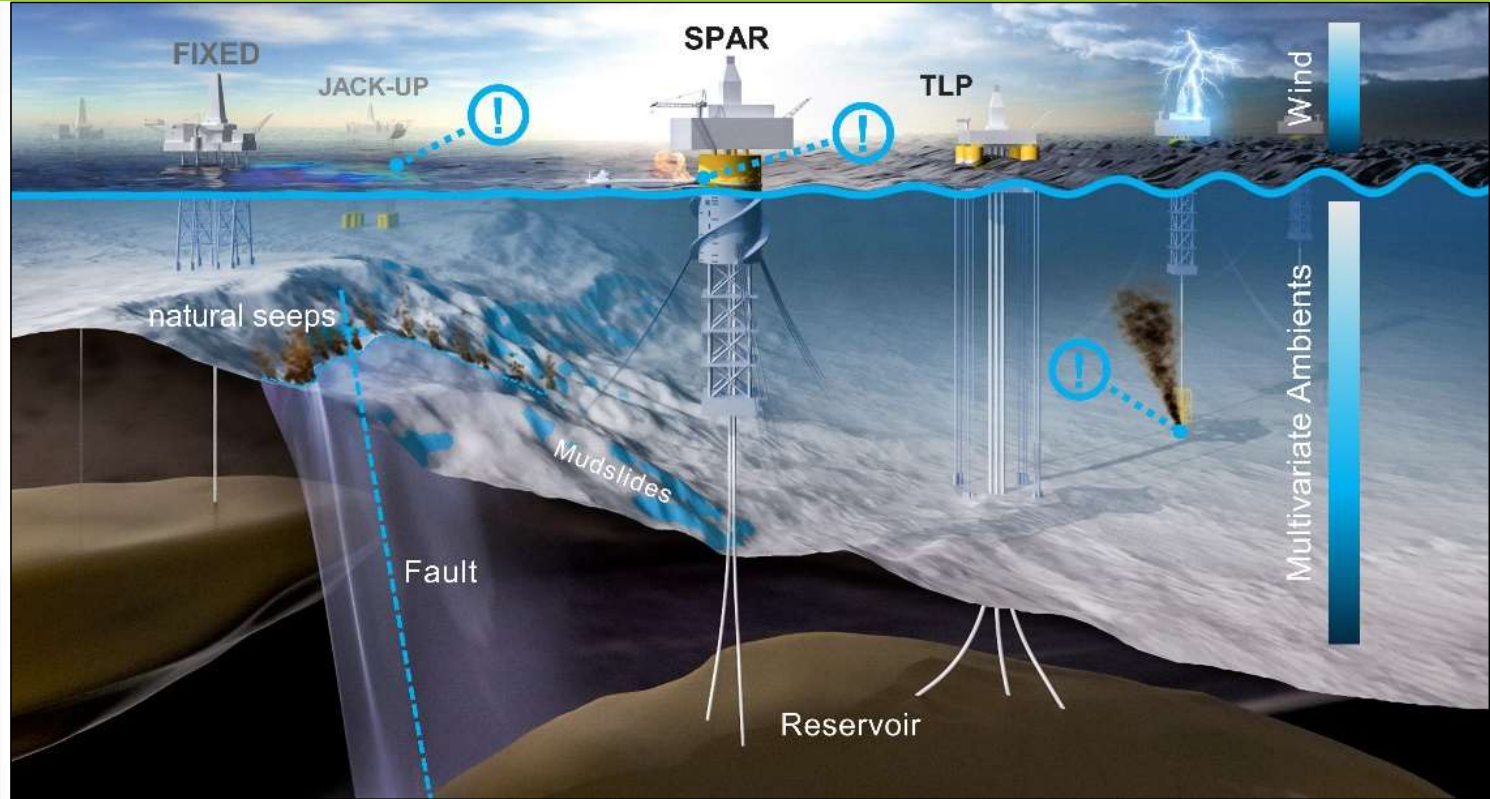
Assessing Offshore Infrastructure Reuse Potential for CS

An Award-Winning AI Model to Forecast Resiliency



Lucy Romeo
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2023 FECM / NETL Carbon Management Research Project Review Meeting
August 30, 2023

The left side of the slide features a background graphic with a grid of faint 'NETL' logos. A larger, semi-transparent 'NETL' logo is centered vertically. Below the logo, the text '2023 FECM / NETL Carbon Management Research Project Review Meeting' and 'August 30, 2023' is displayed in a clean, sans-serif font.

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Overview

Offshore Energy Operations: Potential Risks & Impacts



Solution:

- Applied NETL **big data, big data computing, and advanced modeling** capabilities to **evaluate existing energy infrastructure**
- Developed **multiple machine learning (ML) models & spatio-temporal analytics** to understand **existing infrastructure integrity**
- Enable model-driven insights & visualization with **AIIM (Advanced Infrastructure Integrity Modeling)** published **method-turned-tool (alpha)**



Values Delivered

- Evaluates the **current state of offshore infrastructure** for **reuse potential**
- Inform **lifespan extension, remediation, and safe-use/reuse** strategies
- Support **environmental & operational risk prevention**



AIIM Technical Report (2021): osti.gov/servlets/purl/1780656/

Offshore Risk Modeling Suite



Offshore data, models, & tools supporting...

- Risk prevention & decision-support planning
- Encompasses natural-engineered system
- Measures potential social & environmental impacts

AIIM Advanced Infrastructure Integrity Modeling

- Energy infrastructure-focused
- Published ML/analytical models on evaluation of **infrastructure integrity**

1. Remaining lifespan
2. Risk likelihood

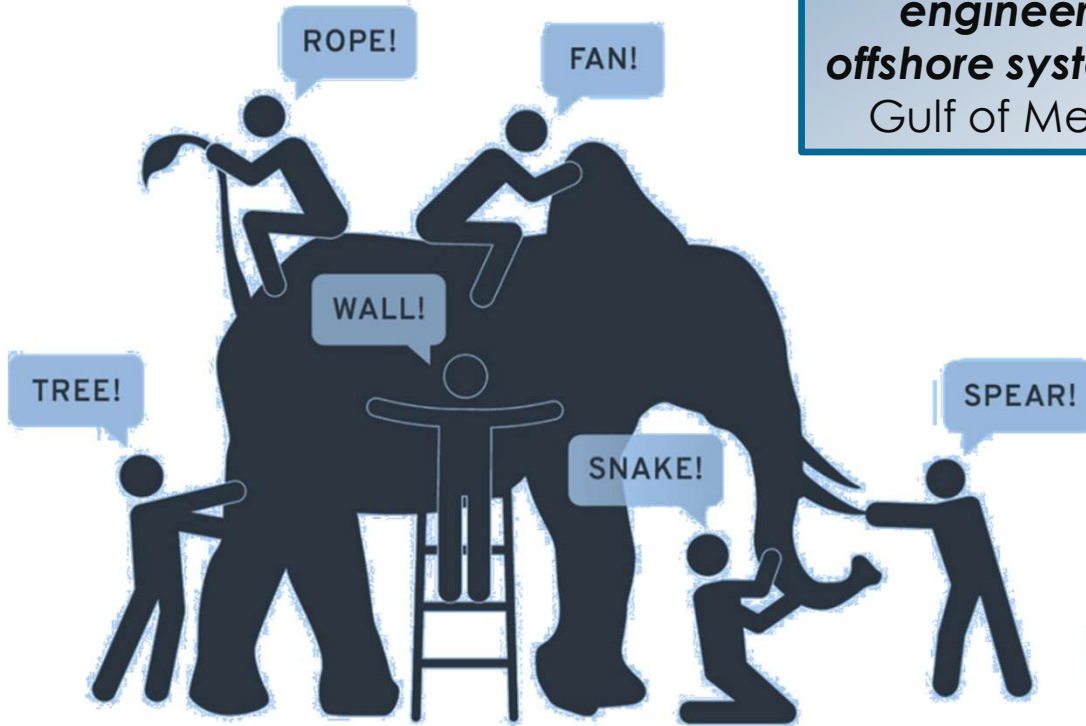




AIIM Approach: Big Data & Big Data Computing-Driven Insights



Using the Whole to Inform Local Trends & Predictions



Data representing the *natural-engineered offshore system* for Gulf of Mexico



- 11k+ platform records
- 26k+ miles of pipelines
- 55k+ well records
- 51k+ environmental layers
- Geohazard layers
 - Landslide prediction surface from NETL's Ocean and Geohazard Analysis smart tool

- 46GB+ biochemical data
- Spatio-temporal production data at the well, platform, and lease block level
- 70+ years of platform incidents
- 30+ years of pipeline incidents
- 50.6GB of monthly ship trackline data



The AIIM Approach:



Evaluating Multi-ML Model & Advanced Analytical Insights

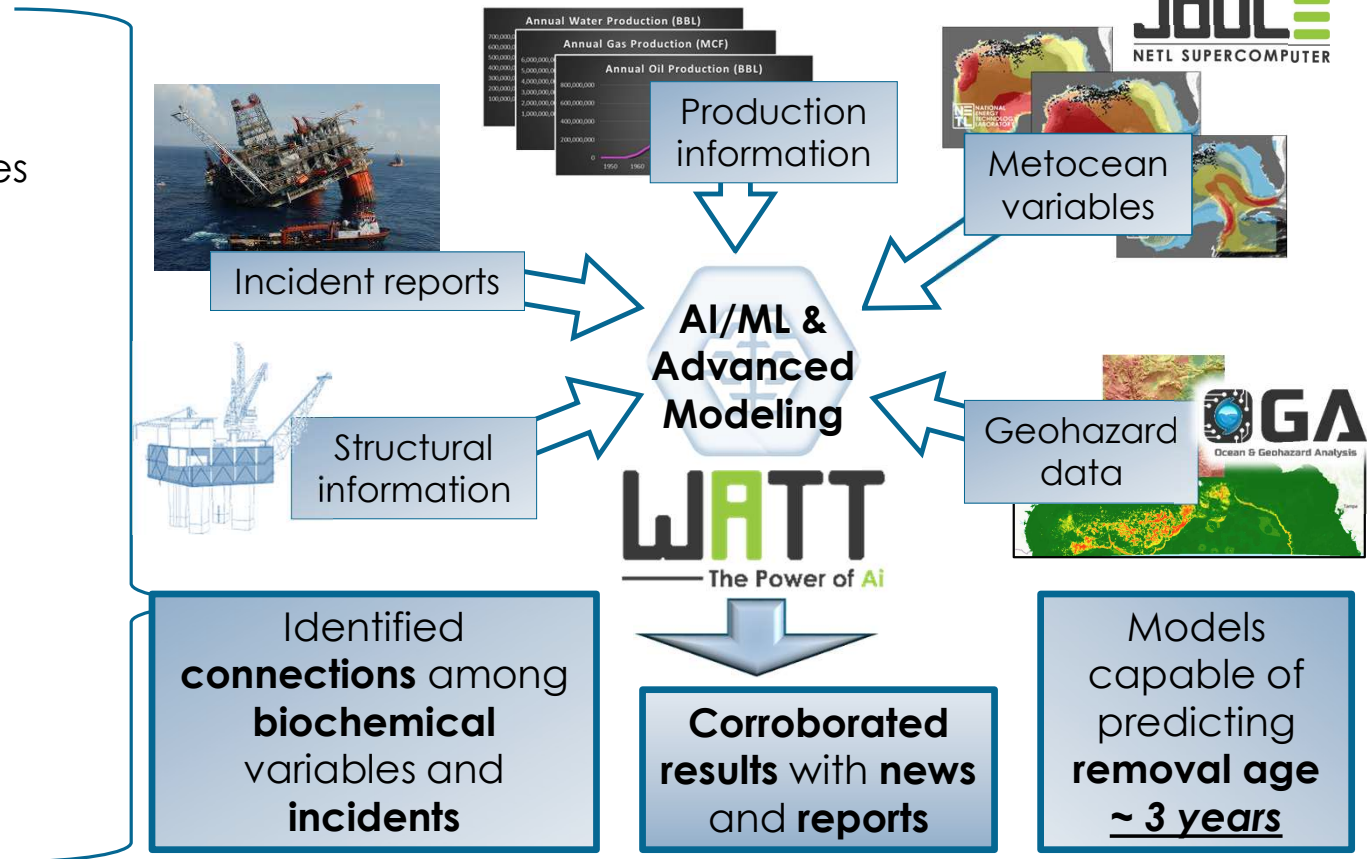
Machine Learning Models

(Dyer et al. 2022)

- Gradient Boosted Decision Trees (GBDT) (2 models)
- Artificial Neural Network (ANN) (2 models)
- Bayesian Network

Advanced Analytics

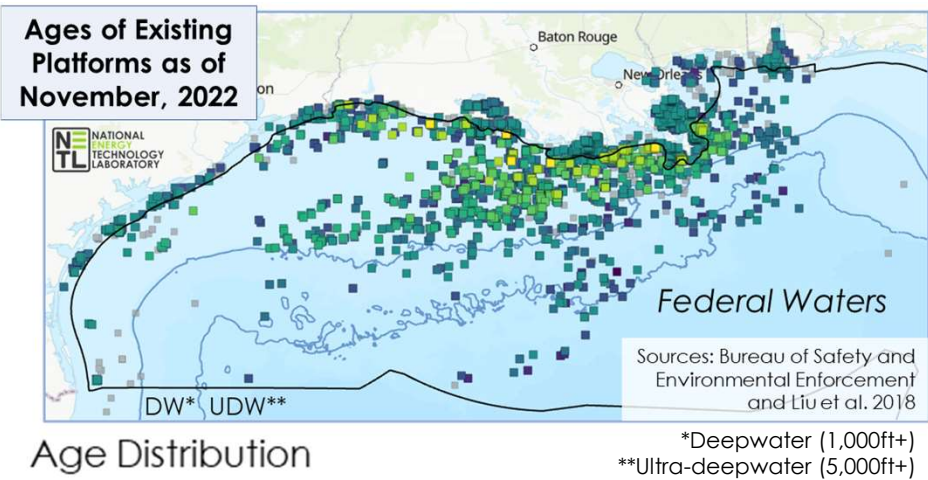
- Geographically Weighted Regression (Nelson et al. 2021)
- Causality/Time Series Analytics



AIM: Research Products & Insights



Evaluating Platform Infrastructure

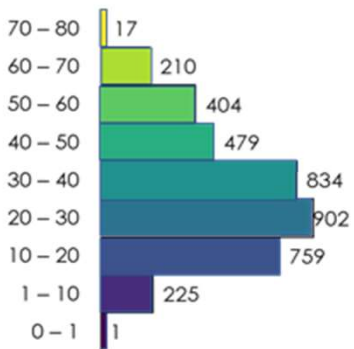


- Integrated **70+ years** of data
- **11k+** structure records
- **1,700+** features
- **Updated incidents & metocean statistics**
- **Updated ML models** capable of predicting removal age within **~3 years**
- **Key stressors** included:

Model	Root Mean Square Error (RMSE)
ANN	5.3 years
GBDT (XGBoost)	3.4 years
GBDT (CatBoost)	3.1 years

- Storm occurrences (wind gust, minimum central pressure)
- Corrosive factors (biochemical variables)

- Number of well slots
- Water depth
- Reported incidents



Comprehensive Platform Dataset to be updated

EDX Energy Data Exchange

(Romeo, 2021)



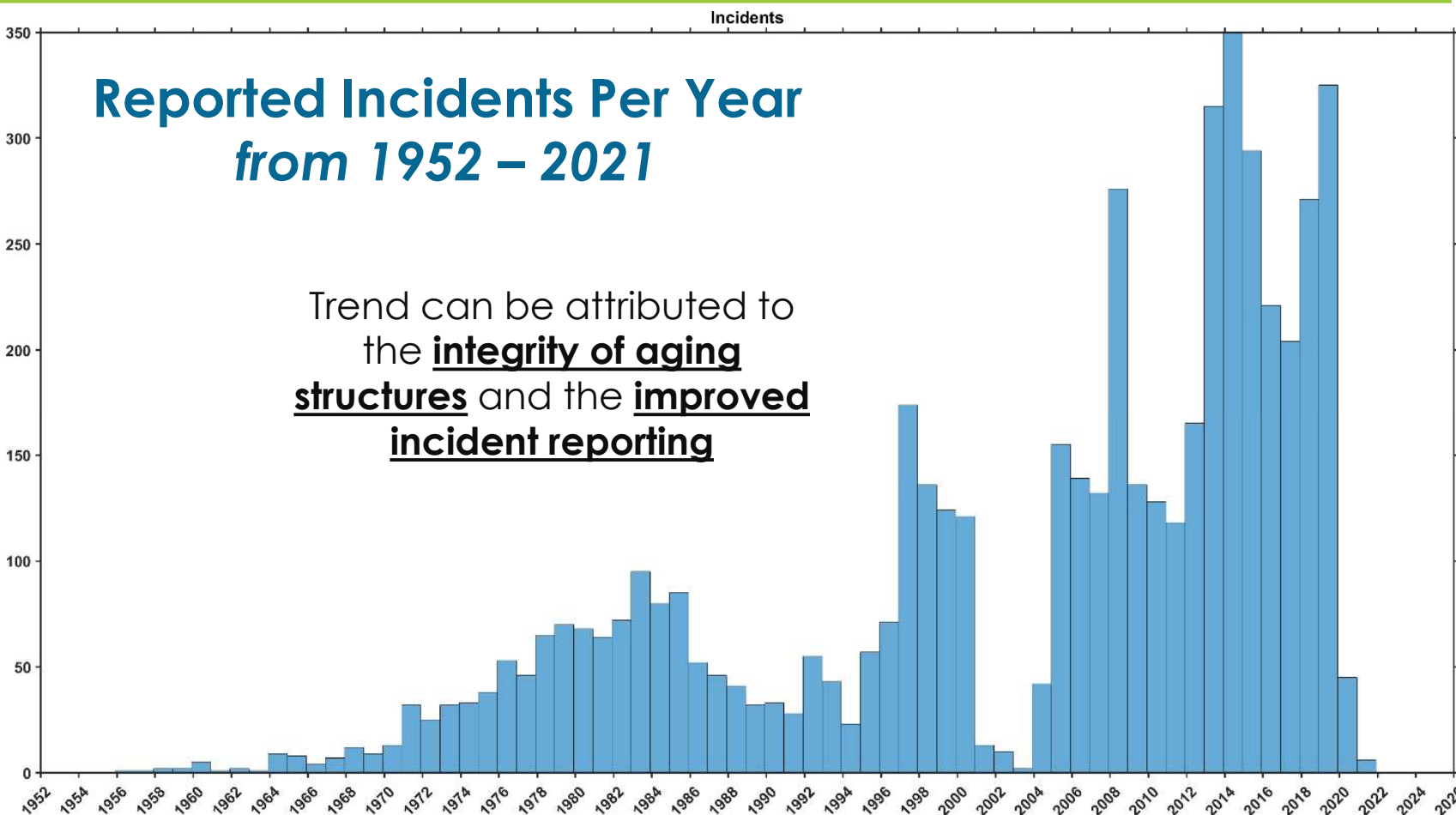
Applied machine learning model comparison: Predicting offshore platform integrity with gradient boosting algorithms and neural networks - ScienceDirect

Evaluating Platform Incidents



Reported Incidents Per Year from 1952 – 2021

Trend can be attributed to the integrity of aging structures and the improved incident reporting

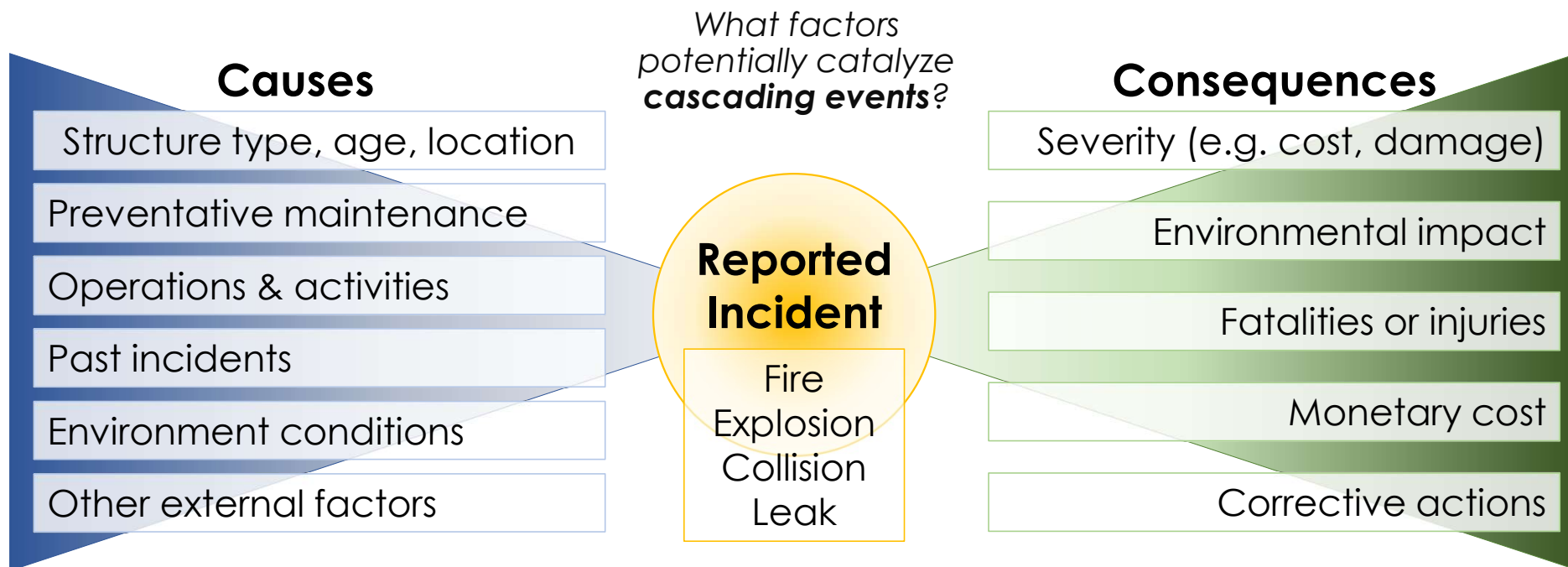


Sources:

- Bureau of Safety and Environmental Enforcement (**BSEE**) & past agencies
- **292 incidents** from **Hurricane Reports**
- **239 incidents** from the Pipeline and Hazardous Materials Safety Administration (**PHMSA**)

Expanding Analytics on Reported Incidents

Examining Risk Cause and Effect



Answer questions such as,

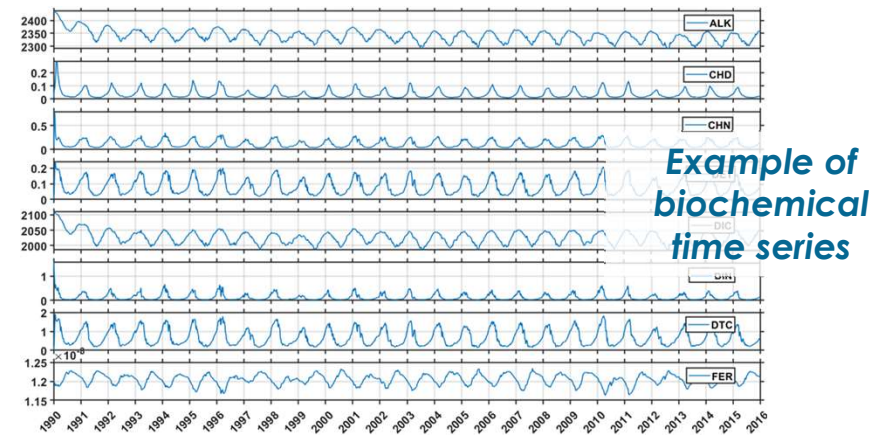
- *At what age are platforms most prone to incidents?*
- *Where are infrastructure more vulnerable to incident?*



Time Series Analytics

Biochemical Variables → Reported Platform Incidents

- Aggregated incidents and biochemical (Yool et al., 2013) time series to estimate **transfer of information**
 - 26 years of biochemical data (1990—2015)
- **Causal relationship was not found**
 - Biochemical variables → incident time series
- **Identified a causal relationship**
 - Biochemical variables → **rate of change** of incident time series



Biochemical properties cause incidents over **two main periods: 10 years and 20 years**

Model

Medusa/Orca (U.K. NOC)

Variables

Alkaline, diatom chlorophyll, nondiatom chlorophyll, detritus, inorganic carbon, inorganic nitrogen, detritic carbon, dissolved iron, dissolved oxygen, biogenic silicon, silicon, diatom phytoplankton, non-diatom phytoplankton, silicate, meso zooplankton, micro zooplankton

AIM: Research Products & Insights



Evaluating Pipeline Infrastructure

- **26k+** miles of pipelines
 - **100k+ locations** (every 1km + end points)
 - **400+ features**
- Added **seafloor metocean data** (floor current, bottom pressure)

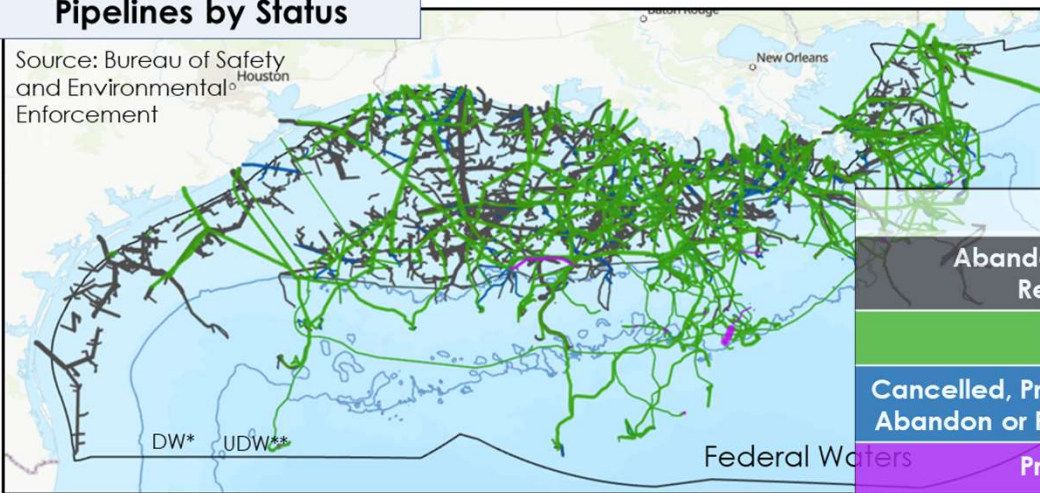
- **Preliminary model runs** capable of predicting **abandonment age** within **~3 years**
- **Key stressors** included:

Biochemical variables
 Installation date/proxy date
 Cathodic code
 Status code
 Facility operator

Model	Root Mean Square Error (RMSE)
ANN	3.3 years
GBDT (XGBoost)	3.1 years
GBDT (CatBoost)	0.7 years** 0.99 R ²

Pipelines by Status

Source: Bureau of Safety and Environmental Enforcement



Status	Miles
Abandoned or Removed	23,838
Active	19,731
Cancelled, Proposed Abandon or Remove	3,914
Proposed	109

Pipeline Database slated for **Fall 2023 Release!**

Database Publication is in preparation!
 (Pfander et al. *in prep*)



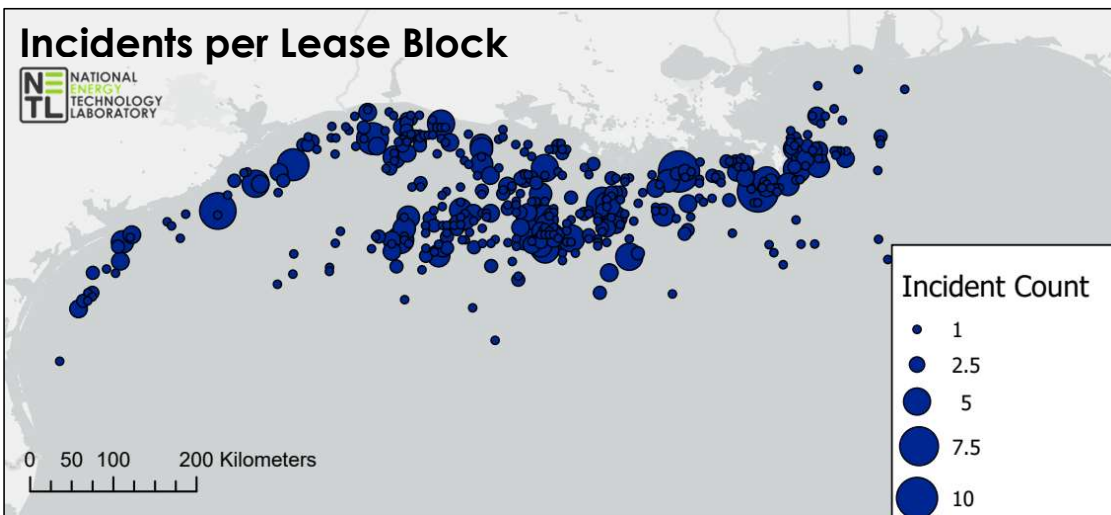
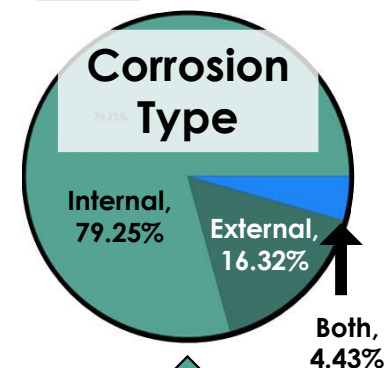
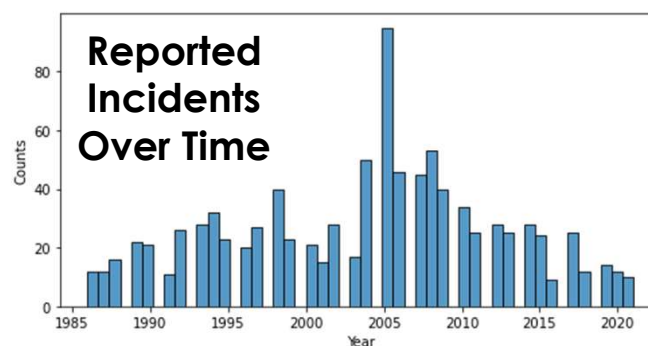
<https://edx.netl.doe.gov/offshore/portfolio-items/assessing-current-and-future-infrastructure-hazards/>

Pipeline Incident Processing



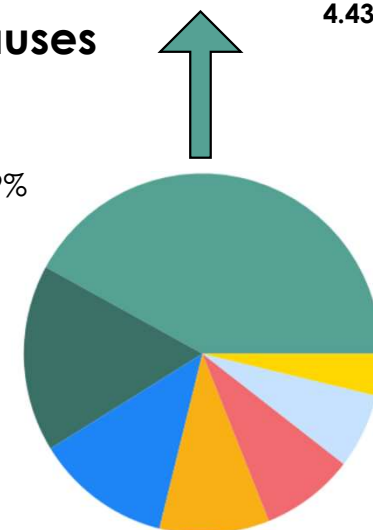
Understanding 30+ Years of Incidents

- Compiled, cleaned, and mapped **970 incidents** (Pipeline and Hazardous Materials Safety Administration)
- **30+ years** of incidents (1986 – 2021)
- **Mapped** more than **80%** to lease blocks
- Calculated **impact-based severity**



Pipeline Incident by Causes

- Corrosion Failure, 42.03%
- Outside Force Damage, 16.79%
- Natural Forces, 12.30%
- Other, 9.95%
- Material Failure, 8.45%
- Equipment Failure, 6.74%
- Incorrect Operation, 3.74%

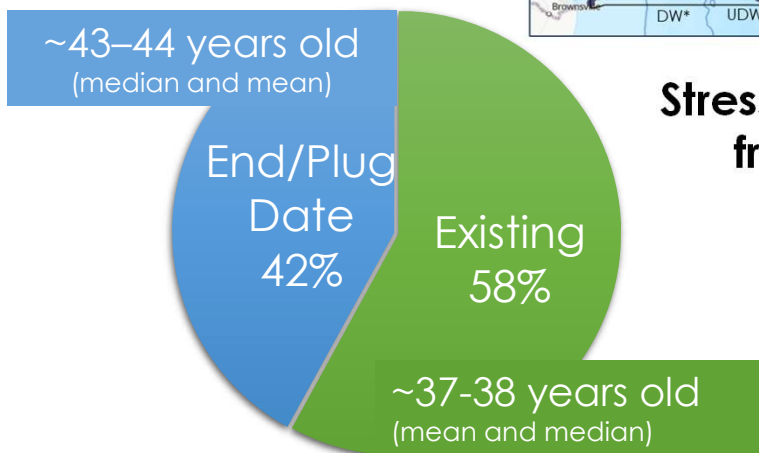
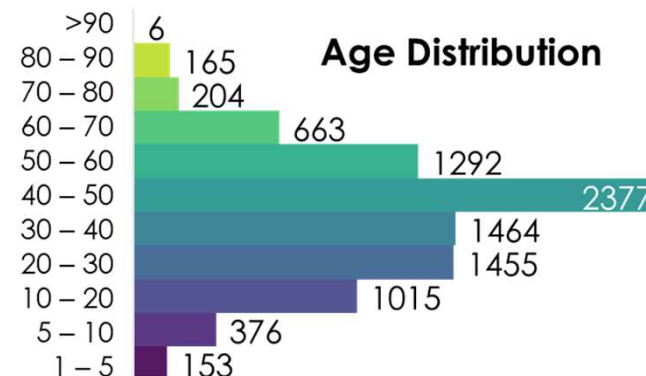
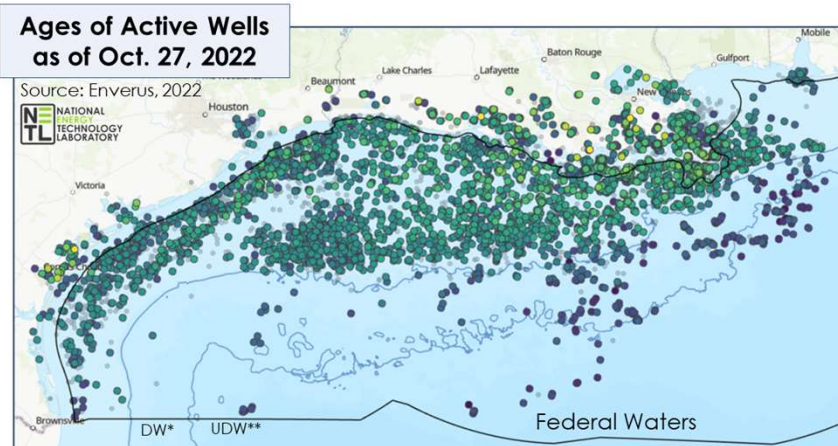


Integrating Well Infrastructure



Utilizing Past Research to Inform New Insights

- Compiled **55k+** well records with **500+** publicly available features
- Acquired **350+** incident records from **National Response Center** reports



Stressors Identified from Literature:

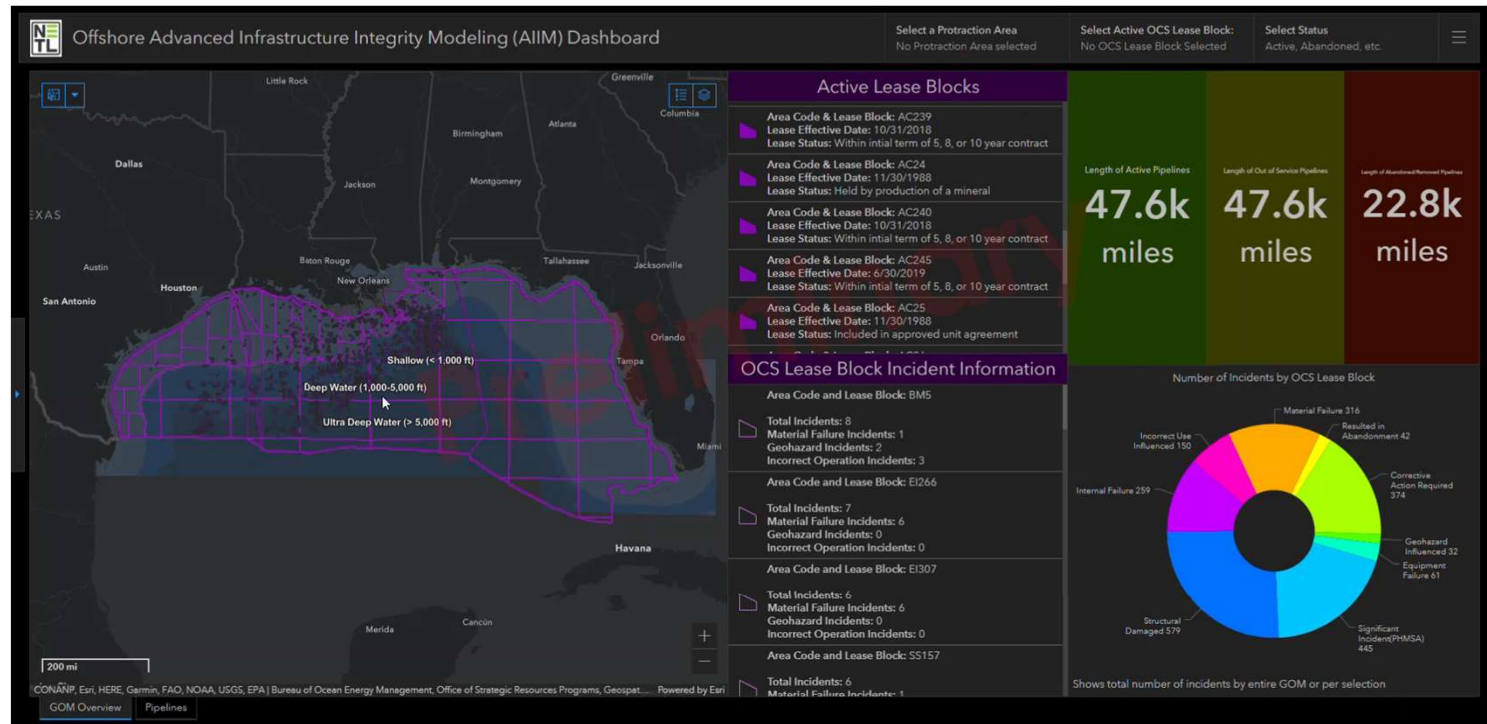
- Age (Dilmore et al., 2015)
- Type (Kiran et al., 2017)
- Concrete type and installation (Wang et al., 2016; Kiran et al., 2017; Wise et al., 2019; Rocha-Valadez et al., 2014)
- Water depth (Wise et al., 2019)
- Corrosion (Kiran et al., 2017)
- Direction (Lackey et al., 2021)
- Pressure and temperature (Rocha-Valadez et al., 2014; Wang et al., 2016; Kiran et al., 2017)
- Seismic/tectonic activity (Kiran et al., 2017)
- Geology (Dilmore et al., 2015; Kiran et al., 2017)

AIIM Dashboard (alpha)



Delivering Data- and Model-Driven Insights

- Developed as an **ESRI Dashboard** to support data visualization & interrogation
- Contains **pipeline data** and model results
- Adding in **updated platform data** and model results
- Enable spatially querying by **areas of interest** (lease blocks, protraction areas, etc.)



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