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Better Call Trawl Challenge Technical Report

U.S. Department of the Interior
Bureau of Ocean Energy Management
Sterling, VA

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Sterling, VA

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List of Abbreviations and Acronyms

Short form	Long form
BOEM	Bureau of Ocean Energy Management
GPS	global positioning system
MMP	Marine Minerals Program
NASA	National Aeronautics and Space Administration
OCS	Outer Continental Shelf
OCSLA	Outer Continental Shelf Lands Act
TOP	trawling optimization platform
SFR	sea floor rate
RSR	at-risk swim rate
TSR	trawling success rate
TVR	trawling volume rate
USGS	US Geological Survey

1 Overview

The Bureau of Ocean Energy Management (BOEM) and the National Aeronautics and Space Administration (NASA) launched the Better Call Trawl Challenge through the NASA Tournament Lab on the HeroX platform. The focus of the challenge was to better understand the effectiveness of current sea turtle relocation trawling methods during offshore dredging operations.

2 HeroX Challenge Model

HeroX is an online crowdsourcing platform that connects organizations with a global community of innovators to solve complex challenges and drive innovation. Clients from a variety of industries post challenges on HeroX, inviting anyone to propose solutions and compete for monetary prizes. Past challenges have resulted in innovative solutions for space exploration, health, and more. The platform's open and inclusive approach to problem-solving has democratized the innovation process, bringing together diverse perspectives and skill sets to tackle complex challenges.

3 Project Details: Better Call Trawl

The Outer Continental Shelf Lands Act (OCSLA) provides BOEM the authority to manage minerals in the Outer Continental Shelf (OCS) and the requirement to provide environmental oversight. BOEM's Marine Minerals Program (MMP) authorizes the use of sand, gravel, and/or shell resources from the OCS for shore protection, beach nourishment, and wetlands restoration. Extraction of these resources from the seafloor may require large trailing suction hopper dredges and other associated equipment which could impact protected species. As the lead Federal agency charged with responsibly managing OCS sediment resources, BOEM partnered with NASA to develop new tools to conceptualize ways to protect and conserve endangered and vulnerable species during dredging operations. Sea turtles near the seabed are at risk of being caught during dredging operations and injured, often lethally. To reduce the risk to these Federally protected species, specialized trawling vessels are contracted to catch and relocate turtles away from the areas before and during dredging operations. However, little is known about how effective current relocation efforts are in preventing harm to sea turtles and what opportunities may exist for improvements.

BOEM and NASA launched the Better Call Trawl Challenge through the NASA Tournament Lab on the HeroX platform. The focus of the challenge was to better understand the effectiveness of current sea turtle relocation trawling methods for protecting sea turtles during offshore dredging operations. The competition invited data scientists, engineers, statisticians, and other scientists to analyze BOEM's data, evaluate the effectiveness of current sea turtle relocation trawling practices and develop an analytical tool that can help improve future protection efforts.

The Better Call Trawl Challenge launched on September 12, 2022, and closed on December 15, 2022. The challenge received over 58,000 views, 181 people followed the challenge and 11 submissions were received. The winner announcement took place on March 9, 2023. An award of up to $40,000 in prizes for top solutions was offered and $22,500 was awarded. The challenge was open to anyone age 18 or older participating as an individual or as a team from any country, as long as U.S. Federal sanctions did not prohibit participation.

3.1 HeroX Challenge Statement

HeroX worked with BOEM for five months to design the guidelines for the challenge. This included a detailed exploration of the problem landscape and available data. Crowdsourcing challenges require the problem to be decomposed to its most rudimentary level and then presented in such a way that non-experts, or even people unfamiliar with the area altogether, can understand the problem, why it's important, and apply their unique perspectives to a solution.

The challenge statement[1], as it originally appeared

> We all like beautiful sandy beaches, and we all love the sea turtles that nest on them, right? But considering climate change and future sea level rise projections, how do we continue to maintain healthy beaches in harmony with sea turtles? - that's the crux of this challenge.
> To preserve our beautiful sandy beaches, the Bureau of Ocean Energy Management (BOEM) authorizes giant dredges to vacuum up sand from the bottom of the ocean to replenish eroded beaches. In the process of collecting sand, however, sea turtles resting near or on the seafloor can be sucked up by the dredge and can be injured, often lethally.
>
> Over twenty years ago, a team of experts developed sea turtle relocation trawling methods to try and prevent sea turtles from being injured or killed during dredging. Essentially a fishing net is dragged along the seafloor to capture sea turtles near where dredging is taking place. These captured sea turtles are then moved out of the dredge area to keep them safe.
>
> The trawling, catch, and relocation of sea turtles has drawbacks. It is thought that only the sea turtles near or on the seafloor are at risk of being sucked into the dredge. But trawling could be capturing sea turtles swimming above the sea floor, as well as any other creature on or near the sea floor, that may otherwise not be impacted by the dredge. Furthermore, the act of catching sea turtles and moving them could injure the sea turtles and is likely stressful. So the trick is to catch and relocate as many at-risk sea turtles (those less than two meters above the sea floor) as possible, without disturbing the non-at-risk sea turtles (those more than two meters above the seafloor) or other creatures that should not be caught.
>
> Where you come in:
>
> The efficacy of sea turtle relocation trawling has yet to be quantitatively tested. BUT BOEM is 'swimming' in great data - and they need your help! Your use of these unique datasets, and potentially data from other sources, will help BOEM understand more about:
>
> - How many at-risk sea turtles sea turtle relocation trawling actually catches and moves
> - How many non-at-risk sea turtles are captured and moved
> - How the efficacy (at-risk sea turtles/ non-at-risk sea turtles captured) changes over the period of dredging; Or based on the behavior of the sea turtles (directed swimming, migrating, resting), etc.
> - What additional data could be collected to bolster your confidence in the conclusions

[1] See https://www.herox.com/BetterCallTrawl

- How current sea turtle relocation trawling methods can be modified to increase at-risk sea turtle catch rate while decreasing the catch rate of non-at-risk sea turtles and other bycatch

The Challenge seeks analytic tools (e.g., decision dashboards, data markdown files/notebooks, analytic reports) to demonstrate projected sea turtle relocation trawling effectiveness, help guide new scientific studies, and improve future sea turtle relocation trawling effectiveness. Up to 4 winners will share in a $40,000 prize purse.

Tackle this challenge and the next time you are enjoying your favorite drink on a white sandy beach you can know that you helped keep beaches sandy AND sea turtles safe.

BOEM provided two primary data resources for use by the solvers and allowed access to additional datasets provided by the solvers. *The details on the data*[2]*, as it originally appeared on is as follows:*

1. Tag data of individual sea turtle behavior collected using Inertial Measurement Unit (IMU) tags, which have accelerometer and depth sensors and thermometers, attached to sea turtles. There are data from two tagging locations: one in the Gulf of Mexico which has data from three tagged turtles displaying different types of behaviors (e.g., swimming, resting, diving) in shallow and deeper coastal areas, and one in the South Atlantic (Cape Canaveral, FL) which has 8 turtles in a mixture of shallow shoal and coastal areas. Sea turtles were not captured and released in active dredging areas, so it is unlikely that they were captured in a trawl. All behaviors are assumed to be 'normal' behavior. Because these individual turtle behavior data and the below trawl data are not taken from the same area, the individual behavior data are assumed to be representative. Additional information about the data and the scenarios of turtle behavior is provided in the Assumption section below.

    1. Gulf of Mexico data are organized into four folders, one for each species and behavior type. Each folder has two .csv files, one containing accelerometer data, and one containing depth and temperature data. A full data dictionary is contained within the data files provided.

    2. Cape Canaveral data contains both accelerometer/depth/temperature data, as well as lat/lon/date/time data, since these turtles were tagged with both satellite location tags and accelerometer/depth/temp tags. These data are organized into eight .csv files. Each file contains time matched GPS and behavior data (accelerometer/depth/temp). A full data dictionary is contained within the data files provided.

2. Trawling data. These data include information on the catch for each trawl for two dredge areas (BA45 and BA143), as well as spatial files describing the dredge area (before and after dredging), and the capture and release locations of sea turtles. Variables include trawl duration, number, size and species of turtles captured.

Critically, several assumptions were made regarding the data and the interaction between sea turtles, trawling vessels, and trailing suction hopper dredges. These assumptions were critical in supporting solvers from outside this subject area in applying their data expertise to the problem. The assumptions are detailed in section 5.4.

The full Challenge Guidelines are available in Appendix A.

[2] See https://www.herox.com/BetterCallTrawl

4 Challenge Outcomes

The first place, $20,000 prize was awarded to Ovidiu Dobre of Sibiu, Romania for his submission TOP - Trawling Optimization Platform. Ovidiu also received the $2,500 prize for the Best Trawling Recommendation.

BOEM will leverage insights and lessons from this challenge to continue exploring the best methods for reducing injury to sea turtles during dredging and relocation trawling operations. The data analysis platform and associated recommendations provided by Ovidiu's winning solution provided an innovative approach to analyzing relocation trawling data that will be used to inform future BOEM decisions. Remaining prize funding that was not awarded was used by HeroX to clean a database of historic relocation trawling efforts. This database can then be used to further examine capture and relocation trawling and test hypotheses developed through the challenge.

4.1 Winning Entry: TOP - Trawling Optimization Platform

The following information was modified from the winning challenge submission and represents the solver's interpretation of the data. These recommendations are from the solver, Ovidiu, and are based on analysis of the limited data set provided in the challenge.

TOP - Trawling Optimization Platform is a data analysis system designed to offer recommendations on trawling schedule and route optimization.

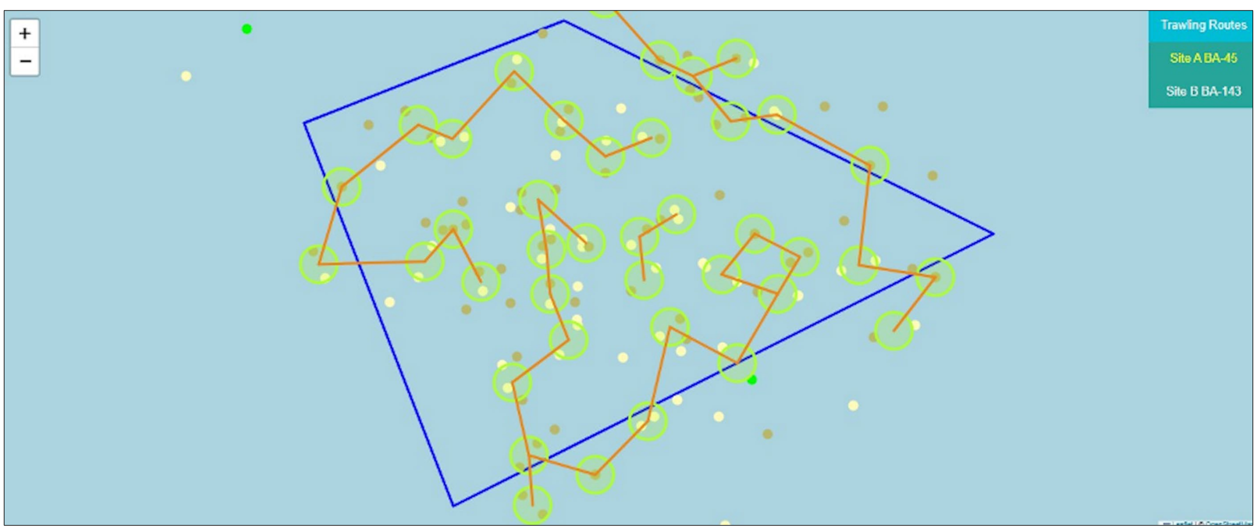

Figure 1. Trawling Optimization Platform

As a data analysis platform, TOP is custom designed to handle data resulting from:

- Monitoring sea turtle behavior from two specific areas (Gulf of Mexico and Cape Canaveral)
- Trawling operations and sea turtle relocation from two specific areas (BA-45 an BA-143)

The platform provides data visualizations tools, allowing insights into sea turtle activity, as well as providing a perspective into the efficiency of trawling operations for sea turtle relocation.

For example, the solution provides a dashboard to visualize sea turtle activity phases which were based off acceleration and depth data from individual turtles (phase 0 - on the sea floor, phase 1- at-risk swimming (<2m from sea floor), phase 3 - safe swimming, and phase 4 - water surface) (Figure 2).

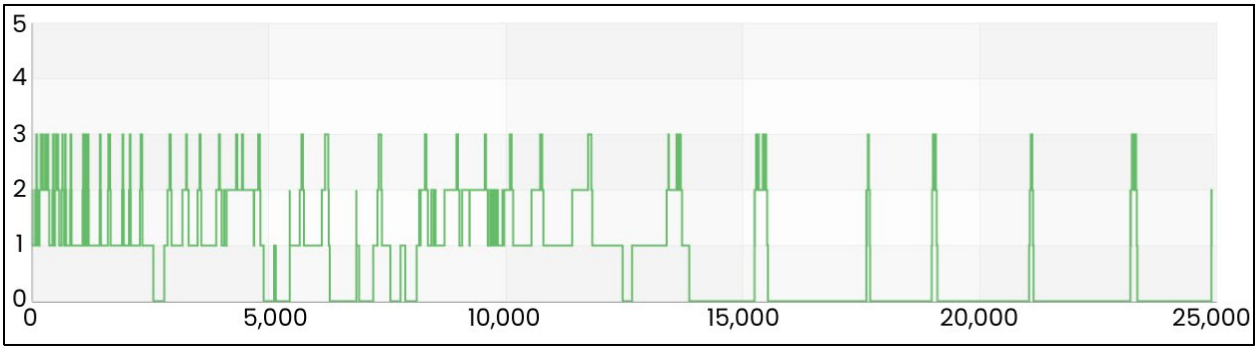

Figure 2. Sea turtle activity phases through time for a sea turtle A tagged at Cape Canaveral.
Sea turtle activity phase definitions: phase 0 - on the sea floor, phase 1- at-risk swimming (<2m from sea floor), phase 3 - safe swimming, and phase 4 - water surface.

The platform introduces a few statistical indicators, such as the Sea Floor Rate (SFR), At-Risk Swim Rate (RSR), Trawling Success Rate (TSR) and Trawling Volume Rate (TVR). See Section 6. Definitions.

Interestingly, analysis showed that, on average, 95% of tow operations resulted in no turtles relocated (Figure 3), 85% of all successful tow operations resulted in just one turtle relocated, and an overall average volume of 1.16 turtles per each tow operation (Figure 4). Based on statistical results provided by this platform, the solver was able to provide recommendations to increase the volume of sea turtles relocated, as well as decreasing the volume of non-at-risk turtles and by-catch. These recommendations mainly focus on optimizing trawling operations in terms of schedule and routes.

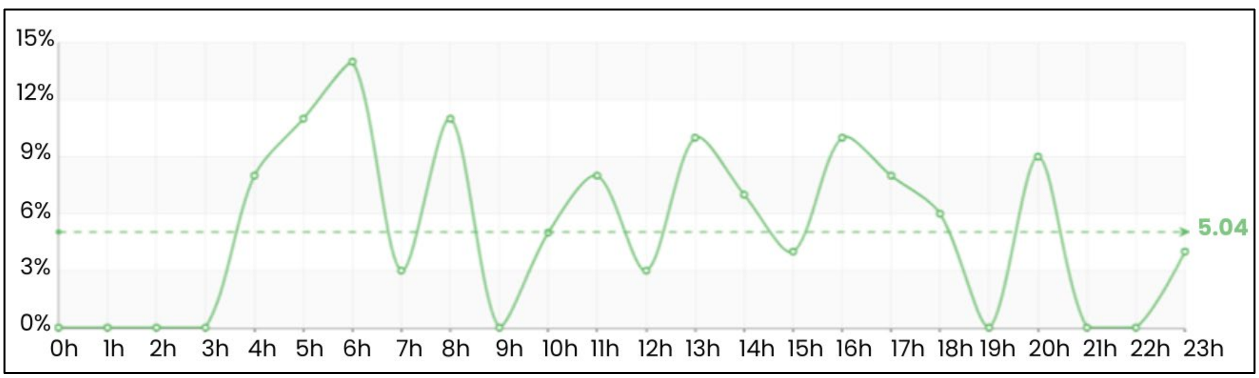

Figure 3. Hourly trawling success rate for site BA-143 over a 24hr period.
Trawling success rate is the number of tows that captured at least one turtle during a given hourly interval divided by the total number of tows.

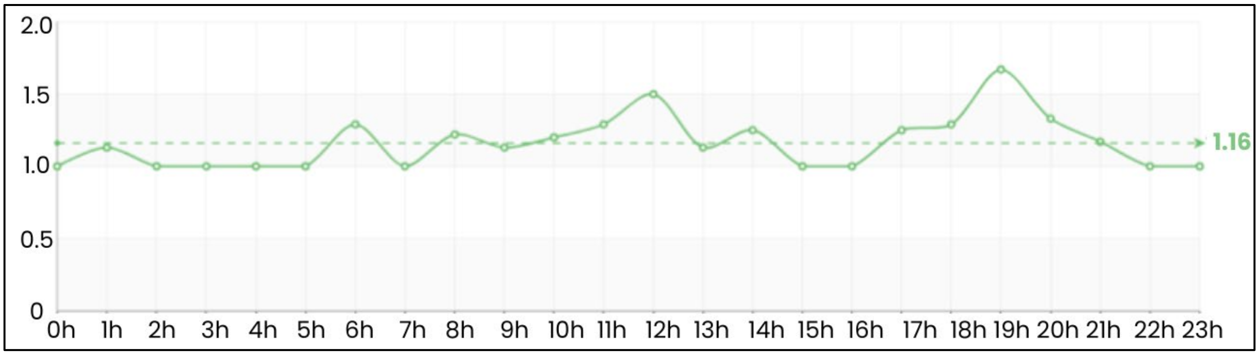

Figure 4. Hourly trawling volume rate for site BA-143 over a 24 hour period.
Trawling volume rate is the number of turtles captured in a given hourly interval (between 0 and 23) over the total number of successful tows performed in the same hourly interval.

One option to increase efficiency of sea turtle relocation trawling would be to focus efforts on the times of days when sea turtles are often captured. For example, analysis of trawling success rate (the ratio of tows which successfully capture and relocated turtles) showed clear diurnal patterns (i.e., higher catches during the day than at night; Figure 3) which were mirrored in the at-risk swim rate (percent of time turtles were on or near the sea floor) (Figure 5, 6). Turtles were more likely to be on or near the sea floor during the day, which are also the times relocation trawls were more likely to capture sea turtles.

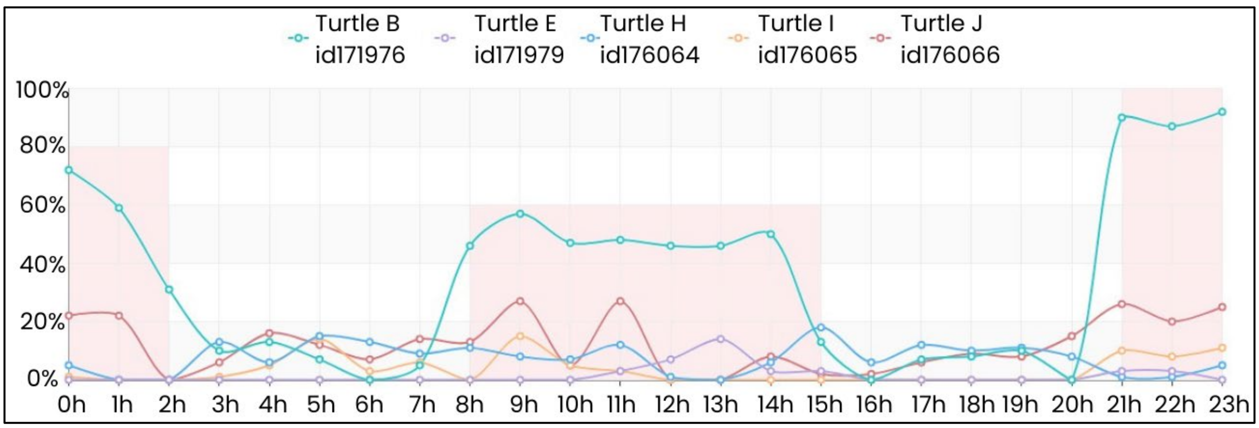

Figure 5. Hourly mean sea floor rate for five turtles tagged in Cape Canaveral.
All turtles had at least three days of recorded data. Shaded regions indicate periods of higher-than-average sea floor rate. Sea floor rate is the percentage of time turtles are spending on the sea floor (called Phase 0 in Turtle Activity Phases) in a given hourly interval (between 0 and 23).

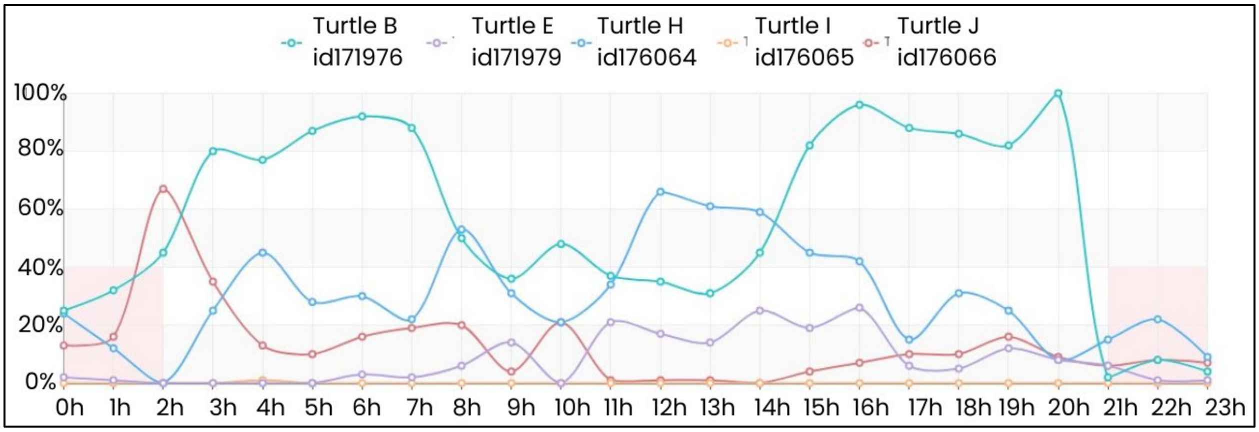

Figure 6. Hourly mean at-risk swim rate for five turtles tagged in Cape Canaveral.
All turtles had at lease three days of recorded data. Shaded regions represent lower than average at-risk swimming rate. Sea floor rate is the percentage of time turtles are spending in the area located 15 feet above sea floor and at-risk to be captured during trawling operations (called Phase 1 in Turtle Activity Phases) in a given hourly interval (between 0 and 23).

The platform also enabled visualization of capture and release location data. This showed that not all turtles were captured in the borrow area. Further analysis showed the potential for turtle 'hotspots' where turtles may congregate and be more efficiently captured and relocated (Figure 7).

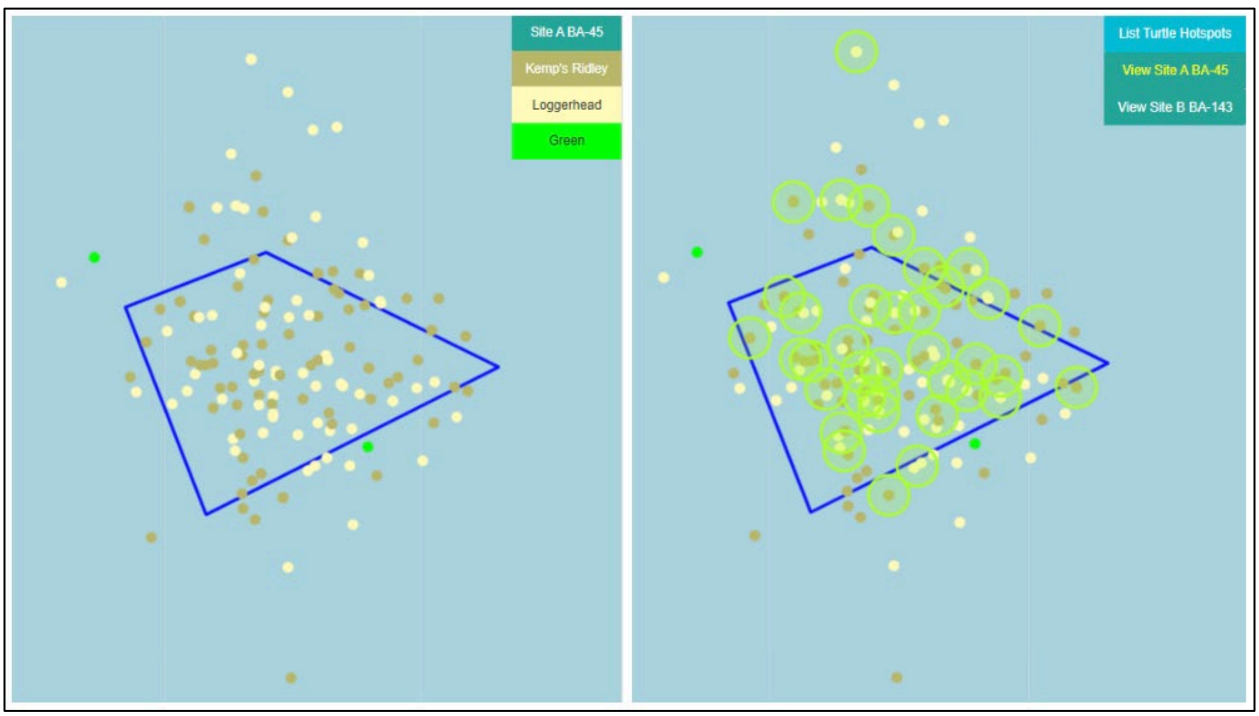

Figure 7. Sea turtle hot spots.
A) Capture locations of each turtle captured in BA-45, and B) identified sea turtle hot spots. Colors indicate sea turtle species; green circles indicate hot spots.

4.1.1 Trawling Schedule and Route Recommendations

As above, the following information is directly from the winning challenge submission.

1. Trawling Schedule Optimization - The first recommendation is to identify the hourly intervals during which sea turtles spend more time on the sea floor. Performing trawling operations during these hourly intervals should increase the number of relocated turtles per each tow operation.

The Sea Floor Rate indicator chart shows identifiable time intervals during which time spent by turtles on sea floor increases:

- between 21h and 2h: it should reflect a sleeping period
- between 8h and 15h: it should reflect a search for food period

These results are consistent with diurnal behavior of sea turtles, sea turtles are mostly inactive during the night and active during the day.

If we consider both the Sea Floor Rate and At-Risk Swim Rate (4.5 m above sea floor) indicators, we can conclude that time interval 21h–2h meets both criteria:

- number of at-risk sea turtles relocated increases
- number of non-at-risk turtles captured decreases

2. Trawling Route Optimization - A second recommendation is to identify turtle hotspots i.e., ocean areas where turtles are found with increased frequency and prioritize trawling effort to cover most of these turtle hotspots.

This approach should result in following improvements:

- substantially reduce the number of tow operations by focusing on trawling routes covering turtle hotspots
- reduce by-catch and trawling costs as number of unnecessary tow operations decreases

4.1.2 Data Quality Recommendations

Additional recommendations were made regarding improving data quality for statistical analysis, to allow for better insight and more reliable conclusions.

These recommendations include:

1. Data To Be Collected In Future Projects - To draw reliable conclusions on turtle activity, such as duration spent on sea floor, the number of monitored turtles should increase and monitoring data should span over multiple days (ideally over multiple weeks)

2. Data Gaps - Missing data was identified in Cape Canaveral tagging files, on a specific hour interval 2 AM - 3 AM during all monitored days for the following turtles: Turtle B - id171976, Turtle J - id176066, Turtle E - id171979, Turtle H - id176064 and Turtle I - id176065. Data gaps can potentially affect conclusions regarding time spent on the sea floor. It is critical to have continuous monitoring data over a range of few days in order to correctly interpret turtle behavior.

Additionally, for turtle Priscilla, monitored for two days in the Gulf of Mexico, acceleration data is missing for the second day. This data gap in acceleration file renders also the depth data partially useless, as depth is correlated with acceleration in order to determine whether sea floor level is reached. Therefore, if depth and acceleration data are provided in separate files, it is necessary to correlate with each other in terms of start and end date & time.

3. Data Size Optimization - When dealing with turtle tagging data extending over long periods of time (e.g., days, weeks), an important question rises over the data size. Data size could potentially reach tens or hundreds of gigabytes, which causes data processing part to be both time and resource consuming.

Thus, we should think to include in log files only data which is required to evaluate turtle activity. For example, on the Cape Canaveral site, the turtle acceleration was sampled 50 times per second, generating 50 log rows every second. On the other hand, the water depth and temperature was sampled only once per second. The analysis algorithm uses information generated once per second, as there is no practical reason to address a more detailed level of turtle activity. Thus, the turtle tagging file can be reduced 50 times (e.g., from 1 GB to 20 MB) without losing any critical information on turtle activity.

4.2 Database quality control, formatting, and visualization

The winning solution was leveraged to build out dashboards for data visualization to give USGS and the U.S. Army Corp of Engineers new tools to review historic sea turtle relocation trawling data. These tools will also position BOEM to do their own analysis. The BOEM and HeroX teams worked with Dr. Kristen Hart (USGS) and Nicole Bonine (U.S. Army Corps of Engineers) to QAQC (quality assurance/quality control) and visualize the portion of the historic sea turtle relocation trawling that has been manually entered from datasheets by the USGS team, led by Dr. Hart.

The project produced several tools to complete QAQC once remaining data has been entered. These tools included reproduceable R scripts, video tutorials, and a dashboard to visualize raw data for data entry errors. Data entered after this project is complete will be cleaned and visualized with these tools.

Two databases were produced. The first is a database formatted for ODESS which will be shared with the U.S. Army Corps of Engineers. The second database was formatted for analysis. Accompanying the analytical-styled database was a second dashboard built to aid in data visualization. This dashboard mirrors the winning solution, by allowing for examination of:

1) High-level project-specific summaries such capture effort (number of turtles relocated/number of tows), number of tow days, and number of sea turtles relocated by species.
2) Project-specific temporal relationships between capture and diel period.
3) Project-specific monthly relationships of capture.
4) Spatial distribution of projects and relocated sea turtles.

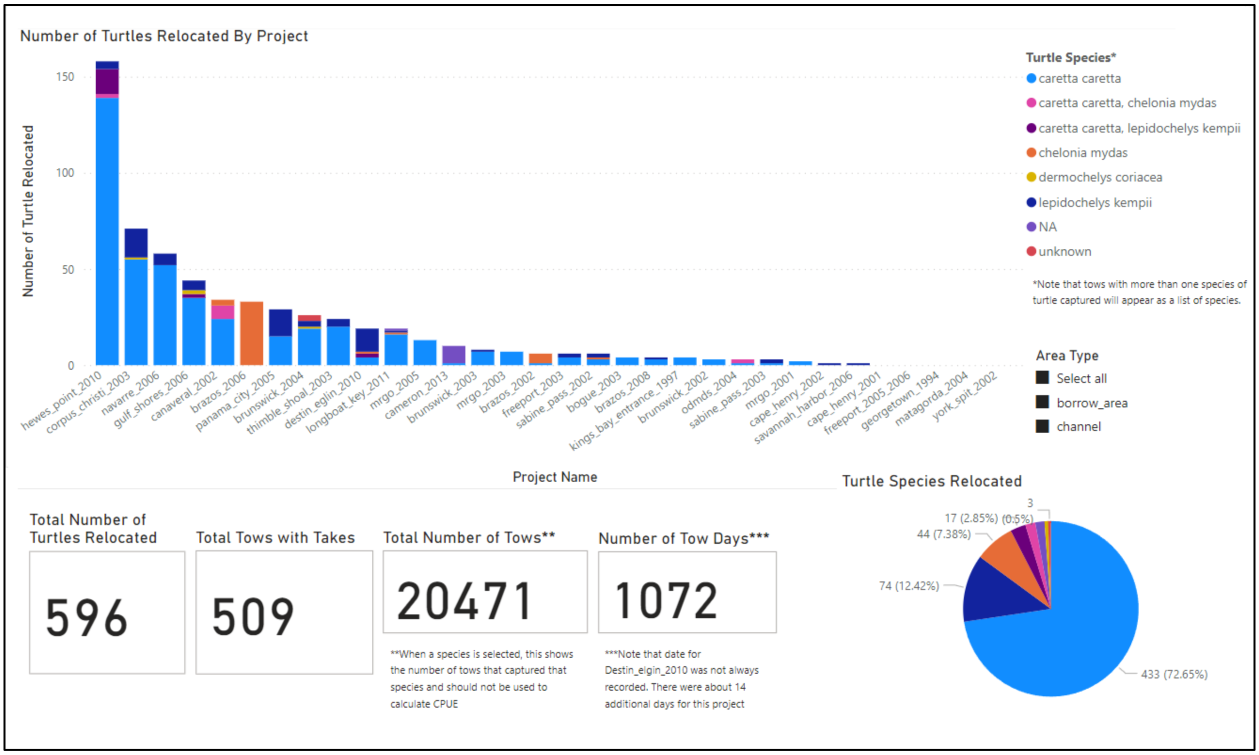

Figure 8: High-level summary of capture and relocation of sea turtles during historic sea turtle relocation trawling projects.
A screenshot of the first page of the dashboard visualizing data from the analytical-styled database. This page shows project-specific summary information of historic sea turtle relocation trawling projects by species.

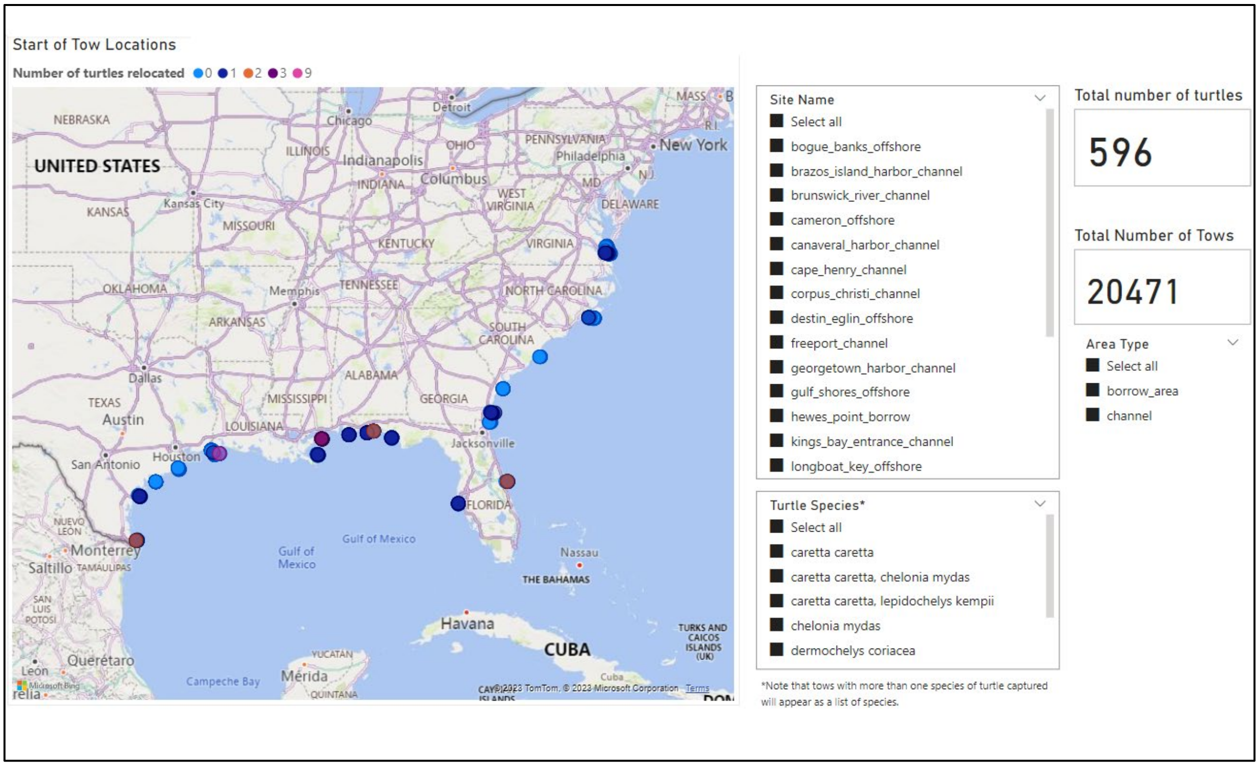

Figure 9: Map of trawling locations for all projects in the historic sea turtle relocation trawling database.
This map is a screenshot of the dashboard built to visualize the data from the analytical-styled database and shows the starting locations of the sea turtle relocation tows. Colors represent different total number of sea turtles relocated. Locations and turtle species can be drilled down to see locations of projects and locations of captures within project areas.

These tool (R scripts, dashboards, video tutorials), will be instrumental in the QAQC, and data visualization of the completed dataset, which when finished will include projects from 1994 to 2023.

5 Key Takeaways from Administering the Challenge

An additional outcome from the process of designing the Better Call Trawl Challenge was identification of key questions as well as in-depth discussion of data availability, data limitations, and knowledge gaps. These were defined in the challenge, and where data limitations and knowledge gaps were identified, assumptions were made. These data, data limitations, knowledge gaps, and assumptions are documented below.

5.1 Key questions

- How many at-risk sea turtles sea turtle relocation trawling actually catches and moves
- How many non-at-risk sea turtles are captured and moved
- How the efficacy (at-risk sea turtles/ non-at-risk sea turtles captured) changes over the period of dredging; Or based on the behavior of the sea turtles (directed swimming, migrating, resting), etc.
- How current sea turtle relocation trawling methods can be modified to increase at-risk sea turtle catch rate while decreasing the catch rate of non-at-risk sea turtles and other bycatch

- What data could be collected in future BOEM field projects to help the analysis and provide even more insight?

5.2 Data availability

Turtle behavior data were gathered from two key sources: Dr. Joe Iafrate and Dr. Kristen Hart (USGS). These data came in different forms. Dr. Hart's data was short segments of specific types of behavior (e.g., foraging, diving, escaping, sleeping), while Dr. Iafrate's data were a longer time series of mixed behaviors. Finding data to use that was geospatially located at a fine scale was difficult.

5.3 Data limitations and Knowledge gaps

- A key data limitation was that the depth of the turtle relative to the sea floor was not known. Tags relate depth as pressure, or distance from the surface of the water. Therefore without exact GPS points, the depth of the sea turtle relative to the sea floor was estimated. This turned out to be a key missing piece of information. Future tags could include GPS locator, or light levels to estimate location.
- Data from similar ecoregions to the borrow areas does not exist (that we know of). Dr. Iafrate's dataset in particular was from a coastal shoal region.
- Trawl net size was not documented in the database
- While there are five species of sea turtles that could be present in the dredge area, there was not enough species-specific behavior data to differentiate by species or life stage (juvenile/adult).
- Given differences in current, and speed of trawl, the volume of water sampled could not be determined.

5.4 Assumptions

5.4.1 Trawling data sets

Trawling: Sea turtle relocation trawlers typically operate at about 2–3 knots with two nets in the water and on the seafloor. Each individual tow is limited to 42 minutes to limit the risk of adverse effects. Each net span in the water was assumed to be 35' wide (70' total sweep width) with a maximum height of approximately 15' off the bottom at the center of each net tapering to the wings.

Sea turtles: Trailing Suction Hopper Dredges are required to keep dragheads on the bottom at all times when the pumps are engaged to constrain the suction field and mitigate entrainment risk. Therefore, during normal operating conditions, only sea turtles on or near the seafloor are at risk of encountering the Trailing Suction Hopper Dredge draghead (within <2 m). US-flagged Trailing Suction Hopper dredges typically operate both port and starboard dragheads. Draghead dimensions vary depending on the specific vessel design and operating conditions; however, for the purpose of this challenge, assume the draghead width is approximately 10'-16' for large Trailing Suction Hopper Dredges operating offshore and the cut depth for each pass of the draghead is approximately 6 inches to 2 feet depending on sediment type.

The site: The dredging site, where trawling occurs, is assumed to be two square kilometers with depths ranging from 28–46 meters. There are anticipated to be a total of 0–50 sea turtles in the defined site area at any given time.

5.4.2 Tagging data sets

Depth data: tagged sea turtles used both shallow and deep habitat. In general for the Gulf of Mexico dataset you can assume a shallow depth of 2–6m and a deepwater depth of 20m. For the Cape Canaveral dataset you can assume a depth of 5–20m. Using depth and accelerometer values you can confirm whether the sea turtle is resting on the seafloor, thus telling you the exact depth of the seafloor.

Location: sea turtles were tagged in different locations but sea turtle behavior is assumed to be representative of sea turtle behavior near the dredging site.

6 Definitions

Sea Floor Rate (SFR) - the percentage of time turtles are spending on the sea floor (called Phase 0 in Turtle Activity Phases) in a given hourly interval (between 0 and 23).

At-Risk Swim Rate (RSR) - the percentage of time turtles are spending in the area located 15 feet above sea floor and at-risk to be captured during trawling operations (called Phase 1 in Turtle Activity Phases) in a given hourly interval (between 0 and 23).

Trawling Success Rate (TSR) - the percentage of tows performed during a given hourly interval (and resulting in at least one turtle captured) over the total number of tows performed in the same hourly interval (between 0 and 23).

Trawling Volume Rate (TVR) - the number of turtles captured in a given hourly interval (between 0 and 23) over the total number of successful tows performed in the same hourly interval.

Triaxial accelerometer tags - measure acceleration in three axes. This data can tell you if the sea turtle is resting, or swimming. X axis = flipper beats, Y axis = dive angle, z axis = roll

Appendix A

The full challenge guidelines, as it originally appeared on the Herox website.[3]

OVERVIEW

We all like beautiful sandy beaches, and we all love the sea turtles that nest on them, right? But considering climate change and future sea level rise projections, how do we continue to maintain healthy beaches in harmony with sea turtles? - that's the crux of this challenge.

To preserve our beautiful sandy beaches, the Bureau of Ocean Energy Management (BOEM) authorizes giant dredges to vacuum up sand from the bottom of the ocean to replenish eroded beaches. In the process of collecting sand, however, sea turtles resting near or on the seafloor can be sucked up by the dredge and can be injured, often lethally.

Over twenty years ago, a team of experts developed sea turtle relocation trawling methods to try and prevent sea turtles from being injured or killed during dredging. Essentially a fishing net is dragged along the seafloor to capture sea turtles near where dredging is taking place. These captured sea turtles are then moved out of the dredge area to keep them safe.

The trawling, catch, and relocation of sea turtles has drawbacks. It is thought that only the sea turtles near or on the seafloor are at risk of being sucked into the dredge. But trawling could be capturing sea turtles swimming above the sea floor, as well as any other creature on or near the sea floor, that may otherwise not be impacted by the dredge. Furthermore, the act of catching sea turtles and moving them could injure the sea turtles and is likely stressful. So the trick is to catch and relocate as many at-risk sea turtles (those less than two meters above the sea floor) as possible, without disturbing the non-at-risk sea turtles (those more than two meters above the seafloor) or other creatures that should not be caught.

Where you come in:

The efficacy of sea turtle relocation trawling has yet to be quantitatively tested. BUT BOEM is 'swimming' in great data - and **they need your help**! Your use of these unique datasets, and potentially data from other sources, will help BOEM understand more about:

- How many at-risk sea turtles sea turtle relocation trawling actually catches and moves
- How many non-at-risk sea turtles are captured and moved
- How the efficacy (at-risk sea turtles/ non-at-risk sea turtles captured) changes over the period of dredging; Or based on the behavior of the sea turtles (directed swimming, migrating, resting), etc.
- What additional data could be collected to bolster your confidence in the conclusions
- How current sea turtle relocation trawling methods can be modified to increase at-risk sea turtle catch rate while decreasing the catch rate of non-at-risk sea turtles and other bycatch

The Challenge seeks analytic tools (e.g., decision dashboards, data markdown files/notebooks, analytic reports) to demonstrate projected sea turtle relocation trawling effectiveness, help guide new scientific

[3] See https://www.herox.com/BetterCallTrawl

studies, and improve future sea turtle relocation trawling effectiveness. Up to 4 winners will share in a $40,000 prize purse.

Tackle this challenge and the next time you are enjoying your favorite drink on a white sandy beach you can know that you helped keep beaches sandy AND sea turtles safe!!

CHALLENGE BREAKTHROUGH

Submit analytic tools and visualizations with data findings and recommend future trawling and data activities.

BACKGROUND

Sea turtle relocation trawling is used as a tool to move turtles and prevent them from being injured or killed during dredging. However empirical evidence supporting sea turtle relocation trawling as a mitigation tool is limited. During dredging, sea turtles can be accidentally sucked into the dredges, so suction heads are kept on the sea floor while pumps are creating suction. In theory this should limit the accidental capture of sea turtles by dredges. However, anecdotal evidence suggests that sea turtles directly on or 1-2 meters above the sea floor could still be at-risk of being injured, possibly lethally, depending on environmental factors and related operational characteristics of the dredge. To prevent these 'at-risk' turtles from being captured by the dredge, a trawling net is used to capture sea turtles and move them out of the way of the dredge. Trawling nets, which are dragged along the seafloor capture sea turtles up to 15ft from the seafloor, as well as any other animals big enough to be caught in the net. This bycatch (i.e., animals that aren't meant to be captured and moved) such as non at-risk sea turtles (those greater than 2 meters above the sea floor), sturgeon or other animals, can be injured or stressed by capture in the trawl. BOEM's Marine Minerals Program seeks to quantify the effectiveness of sea turtle relocation trawling (i.e., the ratio of at-risk sea turtles vs. non at-risk sea turtles which are moved), as well as identify data or methodological advancements to improve sea turtle relocation trawling effectiveness.

What is Sea Turtle Relocation Trawling?

Sea turtles are intentionally captured and relocated out of the area of dredging operations to reduce risk of sea turtles being injured by a dredge. Modified shrimp trawling equipment is used to sweep the sea floor to capture and relocate sea turtles. This involves the dragging of a net (dim 15 x 35ft) along the sea floor behind a trawling boat to capture turtles. Typically a vessel with two trawling nets (example image below) is operated in a given area at the same time, and each trawl can be pulled for no more than 40 minutes to prevent serious injuries to captured turtles. Relocation trawling must maintain a safe distance from the dredge and other vessel traffic in the area. Therefore, the trawler is often not working directly in front of the hopper dredge but is instead continuously working to remove species from the general dredging area. Relocation trawling vessels are smaller than dredges and therefore more restricted by the weather conditions in which they can safely operate. Therefore there are times that the dredge operates, but trawling does not.

Photo credit: East Coast Observers, Inc.

What is dredging?

Trailing Suction Hopper Dredges are specialized ships that have a hollow hull which can be filled with sand. Fitted with powerful pumps, the dredges suck sand from the surface of the seafloor through long intake pipes, called dragarms, and store it in compartments in the hull (a.k.a. hoppers). Trailing suction hopper dredges typically have two dragarms, one on each side of the vessel. A dragarm is a pipe suspended over the side of the vessel with a suction opening called a draghead which sits on the bottom and sucks up sand like the head of a vacuum. Depending on the hopper dredge, a slurry of water and sand is generated from the plowing of the draghead "teeth," by using high pressure water jets, and the suction pumps. The water and sand slurry is pumped into, and distributed within, the vessel's hopper where the sand settles to the bottom and the remaining water is pumped back into the ocean. When the hopper attains a full load, dredging stops and the ship travels to either an in-water placement site, or hooks up to an in-water pipeline, where the dredged sand is offloaded. The average speed for hopper dredges while dredging is between 1-3 knots, with most dredges never exceeding 4 knots. The draghead width is approximately 10-16 feet and approximately 6 inches to 2 feet of sand is removed during each pass of the draghead.

With the solutions from this challenge, modeled trawling scenarios using new or varied relocation or turtle avoidance approaches, which have data-backed confidence, will allow BOEM to intelligently test the approaches in the field and make new recommendations on gear or operation modifications that trawlers can make to increase probability of higher at-risk turtle catch rates and lower bycatch. BOEM will better understand the likely effectiveness of a planned trawling operation under different environmental conditions relative to the risk of lethal capture by dredges. Sea turtle relocation trawling operations will be safer and more effective, and better data will be collected.

What You Can Do To Cause A Breakthrough

Build an analytic tool (online dashboard, data notebook or markdown file, statistical model) that leverages BOEM data including individual sea turtle movement behavior, trawler sea turtle catch data, trawler specification data, environmental and oceanographic data and other resources you find useful, to help BOEM analysts decide how effective current sea turtle relocation trawling methods are and what could be improved by projecting effectiveness.

The Data

BOEM has provided two primary data resources (available in the Resources tab) that include:

1. Tag data of individual sea turtle behavior collected using Inertial Measurement Unit (IMU) tags, which have accelerometer and depth sensors and thermometers, attached to sea turtles. There are data from two tagging locations: one in the Gulf of Mexico which has data from three tagged turtles displaying different types of behaviors (e.g., swimming, resting, diving) in shallow and deeper coastal areas, and one in the South Atlantic (Cape Canaveral, FL) which has 8 turtles in a mixture of shallow shoal and coastal areas. Sea turtles were not captured and released in active dredging areas, so it is unlikely that they were captured in a trawl. All behaviors are assumed to be 'normal' behavior. Because these individual turtle behavior data and the below trawl data are not taken from the same area, the individual behavior data are assumed to be representative. Additional information about the data and the scenarios of turtle behavior is provided in the Assumption section below.
    1. Gulf of Mexico data are organized into four folders, one for each species and behavior type. Each folder has two .csv files, one containing accelerometer data, and one containing depth and temperature data. A full data dictionary is contained within the data files provided.
    2. Cape Canaveral data contains both accelerometer/depth/temperature data, as well as lat/lon/date/time data, since these turtles were tagged with both satellite location tags and accelerometer/depth/temp tags. These data are organized into eight .csv files. Each file contains time matched GPS and behavior data (accelerometer/depth/temp). A full data dictionary is contained within the data files provided.
2. Trawling data. These data include information on the catch for each trawl for two dredge areas (BA45 and BA143), as well as spatial files describing the dredge area (before and after dredging), and the capture and release locations of sea turtles. Variables include trawl duration, number, size and species of turtles captured.

Solvers can also explore secondary datasets, but should focus on the two primary data sets for exploration. Additional data can include environmental covariates (e.g., oceanographic data (provided here), and dredge data (provided in the challenge data in the Resources tab). Please note that BOEM cannot guarantee the quality and reliability of secondary data as they relate to the primary data.

Driving Questions and Assumptions to Validate

In the exploration of the data, solvers should consider the following questions, based on the assumptions listed below, when you submit your solutions:

Questions

1. What could be changed about the trawler equipment and its operation to catch more at-risk sea turtles and less bycatch?
2. What data could be collected in future BOEM field projects to help the analysis and provide even more insight?

Assumptions

Trawling data sets

- Trawling - Sea turtle relocation trawlers typically operate at about 2-3 knots with two nets in the water and on seafloor. Each individual tow is limited to 42 minutes to limit the risk of adverse effects. Each net span in the water is approximately 35' wide (70' total sweep width) with a maximum height of approximately 15' off the bottom at the center of each net tapering to the wings.
- Sea turtles - Trailing Suction Hopper Dredges are required to keep dragheads on the bottom at all times when the pumps are engaged to constrain the suction field and mitigate entrainment risk. Therefore, during normal operating conditions, only sea turtles on or near the seafloor are at risk of encountering the Trailing Suction Hopper Dredge draghead (within <2 m). US-flagged Trailing Suction Hopper dredges typically operate both port and starboard dragheads. Draghead dimensions vary depending on the specific vessel design and operating conditions; however, for the purpose of this challenge, assume the draghead width is approximately 10'-16' for large Trailing Suction Hopper Dredges operating offshore and the cut depth for each pass of the draghead is approximately 6" to 2' depending on sediment type. Turtle data is partitioned by various behavior scenarios:
    - Swimming
    - Resting
    - Swimming or resting in shallow habitats
    - Swimming or resting in deep habitats
- The site - The dredging site, where trawling occurs, is assumed to be two square kilometers with depths ranging from 28-46 meters. There are anticipated to be a total of 0 - 50 sea turtles in the defined site area at any given time.
- Bycatch - While at-risk turtles are the primary focus of this challenge, BOEM is interested in reducing the risk of catching non-at risk sea turtles, other protected species (e.g., Atlantic sturgeon, small tooth sawfish, and giant manta rays), and non-protected species of fish, sharks, rays, etc.

Tagging data sets

- Triaxial accelerometer tags - measure acceleration in three axes. This data can tell you if the sea turtle is resting, or swimming. X axis = flipper beats, Y axis = dive angle, z axis = roll
- Depth data - tagged sea turtles used both shallow and deep habitat. In general for the Gulf of Mexico dataset you can assume a shallow depth of 2 - 6m and a deepwater depth of 20m. For the Cape Canaveral dataset you can assume a depth of 5 - 20m. Using depth and accelerometer values you can confirm whether the sea turtle is resting on the seafloor, thus telling you the exact depth of the seafloor.
- Species - while there are 5 species of sea turtles that could be present in the dredge area, there are likely not enough species-specific behavior data to differentiate by species or life stage (juvenile/adult)..
- Location - sea turtles were tagged in different locations but sea turtle behavior is assumed to be representative of sea turtle behavior near the dredging site.

The Data Transformation

Solvers will run the data through their preferred and ideal analytic tools to create outputs that help BOEM understand trawling effectiveness and plan future field activities. In the process, explain the labor that goes into preparing data for such analyses. What could be done to the data beforehand to make that transformation work less intensive? What data do you feel, if you had easy access to, would make the process easier and also make the analysis more valuable?

PRIZE

Up to four prizes will be awarded to the best submissions received that provide insight into BOEM data, insight into trawling practices, and inform future data and field activities. The first three prizes are tiered and the runner up prize is for a solution that demonstrates a particularly innovative recommendation for improving methods of trawling for sea turtles.

Winners	**Award**	**Award**
1st	$20,000	$20,000
2nd	$10,000	$10,000
3rd	$7,500	$7,500
Best Trawling Recommendation	$2,500	$2,500
Total Prize Purse		**$40,000**

TIMELINE

- Open to Submissions: September 13, 2022
- Submission Deadline: December 15, 2022 @ 5PM ET
- Winners Announced: March 9, 2023

HOW DO I WIN

To be eligible for an award, your proposal must, at minimum:

- Satisfy the Judging Scorecard requirements
- Thoughtfully address the Submission Form questions
- Be scored higher than your competitors!

Solutions should:

- Analyze BOEM data and demonstrate useful insight that can lead to better uses of the data, better trawling method possibilities, or both
- Be analytic tools that BOEM can use to inform their next phase of work that will follow this challenge, ideally testing new methods of relocation trawling based on evidence-based recommendations from this challenge
- Provide specific recommendations on BOEMs data collection and use of data, or trawling methods and ways to improve the relocation practice of at-risk sea turtles, and reduce the risk of bycatch of non-target species (including non-at-risk turtles)
- Use visualization to communicate the analyses and recommendations clearly
- Be scalable and reusable with additional data and for future BOEM projects

Be sure to consider the judging criteria weights in constructing your submission.

JUDGING CRITERIA

Section	Description	Overall Weight
Use of Data	• How well did the solver transform, clean, and work with the data? • How well did the solver present BOEM data in their solution? • How well did the solver integrate BOEM data, with other sources or with the solution, to provide true insight? • How novel is the use of data and data integration and analysis?	20
Tool capability	• How easily can BOEM leverage the tool as-is for upcoming work? • How robust is the tool and its features for providing multiple insights to help solve the problem? • How innovative is the tool in its integration and display of analysis to BOEM?	15
Solution and Data Recommendations	• How helpful are data recommendations provided in the submission for better data collection/creation, and uses of the data? • How helpful are trawling recommendations provided in the submission for future field and trawling study? • How well did the solver use visualizations to demonstrate their recommendations?	30
Use of visualization	• How well did the solver leverage data visualization techniques to show what their analysis yielded? • How easy to understand are the visual tools and aspects of the solution?	25
Reusability	• How applicable is the tool to other and additional BOEM data? • How easily could the tool be adapted for future projects and use with data collected in future field work by BOEM?	10

RULES

Participation Eligibility:

The Prize is open to anyone age 18 or older participating as an individual or as a team. Individual competitors and teams may originate from any country, as long as United States federal sanctions do not prohibit participation (see: https://www.treasury.gov/resource-center/sanctions/Programs/Pages/Programs.aspx). If you are a NASA employee, a Government contractor, or employed by a Government Contractor, your participation in this challenge may be restricted.

Submissions must originate from either the U.S. or a designated country (see definition of designated country at https://www.acquisition.gov/far/part-25#FAR_25_003), OR have been substantially transformed in the US or designated country prior to prototype delivery pursuant to FAR 25.403(c).

Submissions must be made in English. All challenge-related communication will be in English.

You are required to ensure that all releases or transfers of technical data to non-US persons comply with International Traffic in Arms Regulation (ITAR), 22 C.F.R. §§ 120.1 to 130.17.

No specific qualifications or expertise in the fields of ecology, dredging, or trawling is required. BOEM encourages outside individuals and non-expert teams to compete and propose new solutions.

To be eligible to compete, you must comply with all the terms of the challenge as defined in the Challenge-Specific Agreement.

Intellectual Property

Innovators who are awarded a prize for their submission must agree to grant the United States Government a royalty-free, non-exclusive, irrevocable, worldwide license in all Intellectual Property demonstrated by the winning/awarded submissions. See the Challenge-Specific Agreement for complete details.

You may be required to complete an additional form to document this license if you are selected as a winner.

Registration and Submissions:

Submissions must be made online (only), via upload to the HeroX.com website, on or before December 15, 2022 at 5pm ET. No late submissions will be accepted.

Selection of Winners:

Based on the winning criteria, prizes will be awarded per the weighted Judging Criteria section above.

Judging Panel:

The determination of the winners will be made by HeroX based on evaluation by relevant BOEM specialists.

Additional Information

- By participating in the challenge, each competitor agrees to submit only their original idea. Any indication of "copying" amongst competitors is grounds for disqualification.
- All applications will go through a process of due diligence; any application found to be misrepresentative, plagiarized, or sharing an idea that is not their own will be automatically disqualified.
- All ineligible applicants will be automatically removed from the competition with no recourse or reimbursement.
- No purchase or payment of any kind is necessary to enter or win the competition.
- Void wherever restricted or prohibited by law.

U.S. Department of the Interior (DOI)
DOI protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.

Bureau of Ocean Energy Management (BOEM)
BOEM's mission is to manage development of U.S. Outer Continental Shelf energy and mineral resources in an environmentally and economically responsible way.

BOEM Environmental Studies Program
The mission of the Environmental Studies Program is to provide the information needed to predict, assess, and manage impacts from offshore energy and marine mineral exploration, development, and production activities on human, marine, and coastal environments. The proposal, selection, research, review, collaboration, production, and dissemination of each of BOEM's Environmental Studies follows the DOI Code of Scientific and Scholarly Conduct, in support of a culture of scientific and professional integrity, as set out in the DOI Departmental Manual (305 DM 3).