Nurdle Count – A machine learning approach to nurdle classification and quantification - Year 2 Quarter 1 Report

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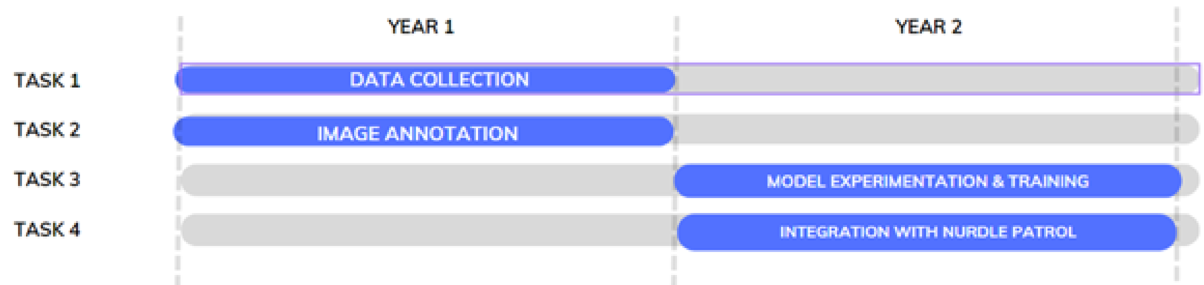
Administration:

The Nurdle Count – A machine learning approach to nurdle classification and quantification was approved for funding on January 8th, 2024, with a requested start date of May 1st, 2024.

Risks and Impacts:

None

Project Tasks:



1) Task 1 - Data collection:

a. **Collect training and test nurdle image data.**
b. **QA/QC collected nurdle image data.**
c. **Research and design AI training methods.**
d. **Develop a standard operating procedure (SOP) for capturing nurdle images.**

Task 1 – Subtasks 1a: Collect training and test nurdle image data

In Year 1, Quarter 1, the research team performed image capturing following the SOP developed for this purpose. Internally, using this SOP, 100 images were captured for Task 2 which is Image Annotation.

In Year 1, Quarter 2, this process was expanded with the help of middle school citizen scientists who are collecting images of nurdles in their classrooms and submitting them via the Nurdle Patrol Website using the QR code below.

In Year 1, Quarter 3, this process was expanded with the help of undergraduate students who collected images of nurdles in class and submitted them via the Nurdle Patrol Website using the QR code.

In Year 1, Quarter 4, this process was expanded with the help of several undergraduate students who added 700 images following strict collection parameters to the Nurdle Patrol Website using the QR codes (Figure 1).

Figure 1: Nurdle Count Image Submission QR Code

This task was completed in Year 1, Quarter 4.

Task 1 – Subtasks 1b: QA/QC collected nurdle image data

In Year 1, Quarter 4, Subtasks 1b (QA/QC of collected images) and 1d (development of the image capture SOP) became closely intertwined, forming an iterative and interdependent workflow. The QA/QC process required a finalized SOP to ensure consistent image quality and metadata, while the SOP's development relied on a fully functional Nurdle Swipe interface to validate and classify images. To support this integration, the Nurdle Swipe tool was upgraded to improve usability and streamline the review process. Notably, text-based buttons such as "swipe right" and "swipe left" were replaced with intuitive visual symbols to reduce user confusion and enhance accessibility (Figure 2).

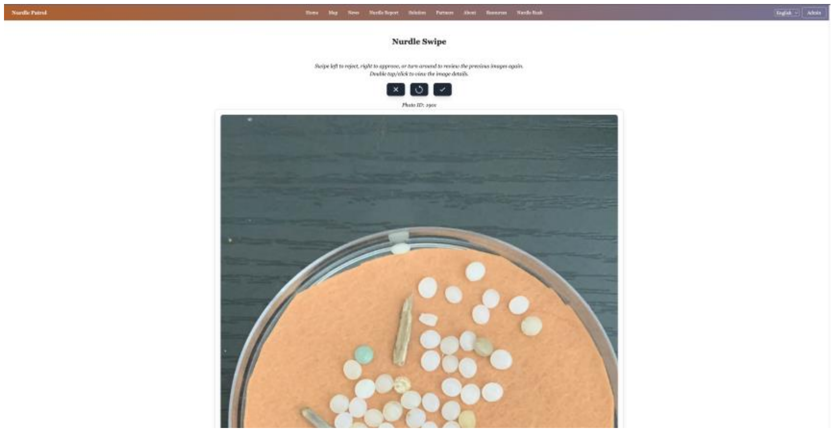


Figure 2: Nurdle Image

Additionally, a standardized list of disqualification reasons was created based on the most frequent issues identified in past image reviews. Validators can now select from this predefined list rather than entering reasons manually, streamlining the QA/QC process and promoting greater consistency (Figure 3).

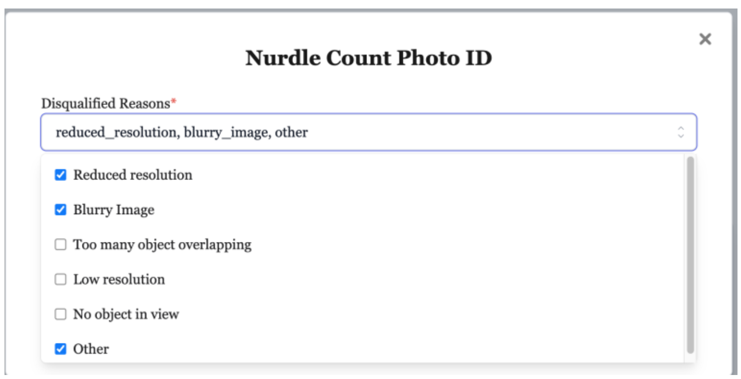


Figure 3: Nurdle Count Photo ID Disqualification Reasons

There is another option that can be used to point to disqualification reasons not yet included in the list, allowing validators to flag new issues. These entries will inform future updates by helping the research team expand and refine the standardized reason list (Figure 4).

Figure 4: Nurdle Count Photo ID Disqualification Reasons Comment

Researchers assessed each image based on clarity, resolution, object visibility, and the absence of obstructions or excessive overlaps. Specifically, a total of 638 images were reviewed through this effort, resulting in 545 images being marked as qualified and 93 as disqualified. Disqualified images were excluded due to reasons such as "reduced resolution" (60 images), "blurry image" (8 images), "too many objects overlapping" (8 images), and "no visible object in view" (19 images), with some images falling into multiple disqualification categories. The qualified set of images will be used for training AI models for nurdle identification. Figure xxx shows the Nurdle Swipe webpage interface, where two images were classed as qualified and disqualified, respectively.

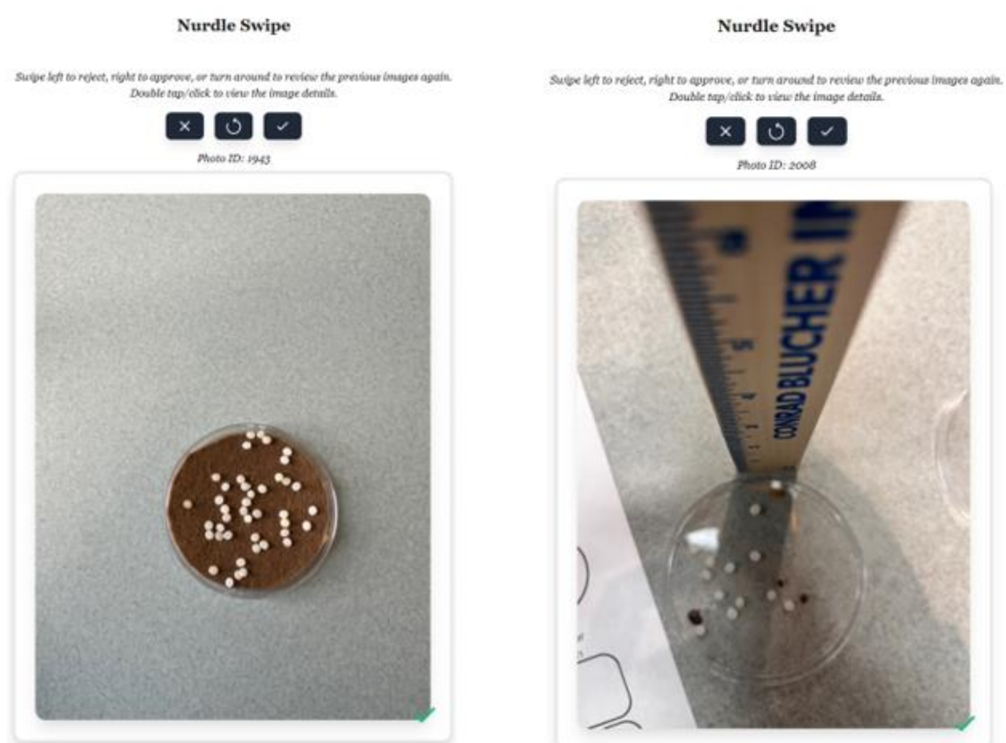


Figure 5: The Nurdle Swipe webpage interface. Left: a qualified nurdle image. Right: a disqualified nurdle image due to blurriness.

Task 1 – Subtasks 1c: Research and design AI training methods

This task was completed in Year 1, Quarter 1.

Task 1 – Subtask 1d: Develop a standard operating procedure (SOP) for capturing nurdle images.

In Year 1, Quarter 1, and in preparation for collecting training and testing the Nurdle image data, the Nurdle Count team first developed two Standard Operating Procedures (SOPs). After an extensive review, two Standard Operating Procedures (SOPs) were created, each tailored to different audiences: internal and external. The internal SOP is designed for use by the research team, while the external SOP is intended for 8th-grade students. Although both SOPs share similar content and workflow, the external SOP is written in language that is accessible and understandable at an 8th-grade reading level.

In Year 1, Quarter 2, project personnel developed a series of three videos detailing the nurdle capture process and made them available via YouTube for a wider audience. To ensure accessibility to a broader audience, YouTube settings enabled these videos to be viewed by kids, and closed captioning was enabled.

These videos are:

Part 1 – Setting up Nurdles in Nurdle Count: https://youtu.be/99pSZEfB37g
Part 2 – Capturing Pictures for Nurdle Count: https://youtu.be/rLRbYLwNVVg
Part 3 - Nurdle Count Image Submission: https://youtu.be/TyTd6OBw9HA

In Year 1, Quarter 3, these videos and materials were leveraged to collect nurdle image data, collect feedback, and improve the Nurdle Count application. This subtask was completed in Year 1, Quarter 3.

For additional information about Year 1, Quarter 4, please see the Subtask 1b section above.

Task 2 – Image Annotation

In Year 1, Quarter 3, to enhance the quality assurance (QA) and quality control (QC) of images collected for training images for Nurdle Count, the Nurdle Swipe feature was developed and successfully integrated into Nurdle Patrol. This process is detailed in Task 1 above.

In Year 1, Quarter 4, we worked to define the preliminary model for detecting support for fast and automatic annotation. Several ML/AI models have been experimented on for nurdle detection. In addition, these model results can be counted as the preliminary results in the early phases and are valued on the way to detect and count nurdles accurately.

Several YOLO-family models, including YOLOv5n, YOLOv8n, and the latest YOLO11n, have been experimented with the current annotated set of images. The models were evaluated based on several metrics, as described in Table 1 below.

Table 1: Model Metrics

Metric	Description
Precision	Of all the objects the model says it found, what fraction are real objects? Higher is better.
Recall	Of all the real objects in the image, what fraction did the model actually find? Higher is better.
mAP@0.5	A combined score (mean Average Precision) that rewards finding objects with at least 50% overlap accuracy. Think of it as an overall "accuracy" at a loose overlap threshold. Higher is better.
mAP@0.5-0.95	Similar to mAP@0.5 but averaged over a range of tighter overlap requirements (from 50% up to 95%). This penalizes sloppy bounding boxes more heavily. Higher is better.

Precision, which indicates the proportion of reported detections that are actual nurdles rather than false alarms, was found to be similar across all three models at around 83%, so false alarms are seldom raised. Recall, which measures the proportion of real nurdles in an image that are detected, was highest for YOLO11n at 78%, compared with 60% for YOLOv5n and 69% for YOLOv8n, indicating that substantially fewer pellets were missed by YOLO11n.

Mean Average Precision at a 50% overlap threshold (mAP@0.5), which combines precision and recall into a single accuracy score under a relatively loose matching requirement between predicted and true nurdle locations, was highest for YOLO11n at 0.823—over ten points above YOLOv5n's 0.732. When a tighter matching requirement was imposed (averaging overlap thresholds from 50% to 95%, known as mAP@0.5–0.95), the improvement offered by YOLO11n became even more pronounced: a score of 0.466 was achieved, compared with 0.336 for YOLOv5n and 0.360 for YOLOv8n. These results indicate that not only are more nurdles detected by YOLO11n, but bounding boxes are also drawn around them more precisely.

In practical applications, the use of YOLO11n can result in far fewer pellets are missed. This combination is critical when undetected nurdles can contribute to pollution or signal production defects, and when false alerts can lead to wasted time and resources. Overall, YOLO11n is demonstrated to provide the best balance of thoroughness and reliability for accurate nurdle detection (Table 2).

Table 2: YOLO Results

Model	Precision	Recall	mAP@0.5	mAP@0.5-0.95
YOLOv5n	**0.83**	0.596	0.732	0.336
YOLOv8n	0.815	0.685	0.777	0.36
YOLO11n	0.828	**0.784**	**0.823**	**0.466**

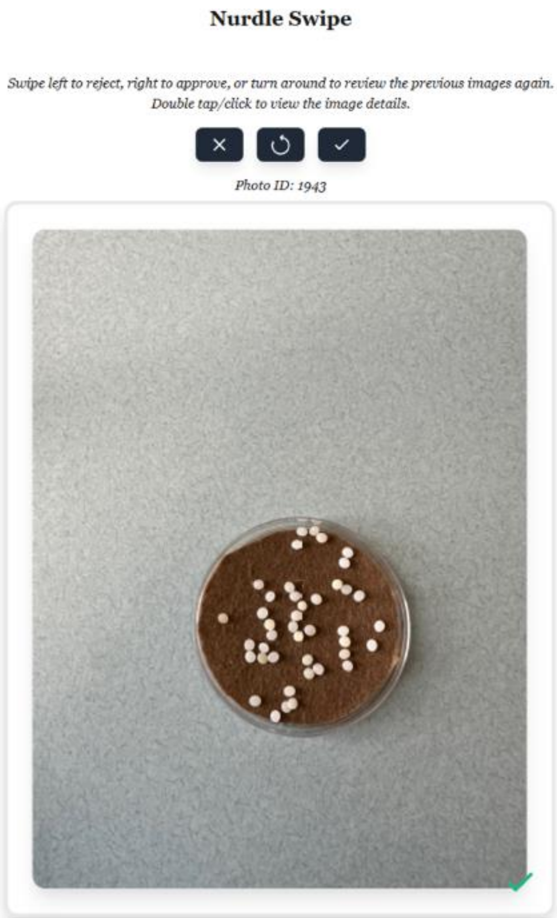
In Task 3 of the project, the research team will continue to work on the automatic annotation workflow, integrate the model for automatic annotation, and experiment with the workflow on the new batch of nurdle images.

Task 3 - Model experimentation and training: ***to be completed in year 2***

In preparation for Task 3, the research team advanced efforts to curate a high-quality image dataset through the Nurdle Swipe tool, a web-based platform hosted on the Nurdle Patrol website (https://nurdlepatrol.org/app/nurdle-swipe). The tool was developed to support AI model training by systematically reviewing nurdle images collected in accordance with the established image collection SOP. Using a swipe interface, researchers approved images that met quality standards (swipe right) or disqualified those that did not (swipe left).

Each image was evaluated for clarity, resolution, object visibility, and freedom from obstructions or excessive overlap. Through this process, 638 images were reviewed, of which 545 were classified as qualified and 93 were disqualified. Disqualifications were attributed to reduced resolution (60 images), blurry capture (8 images), excessive object overlap (8 images), or absence of visible objects (19 images), with some images falling into multiple categories. The resulting set of 545 qualified images will serve as a training dataset for AI-based nurdle identification models, ensuring that only rigorously vetted imagery is used to improve detection accuracy. Figure 5 illustrates the Nurdle Swipe interface, displaying examples of qualified and disqualified images.

Looking ahead, Task 3 will focus on model experimentation and training using this expanded, high-quality dataset. The research team will conduct comparative testing across multiple computer vision architectures to evaluate precision, recall, and mean average precision (mAP) metrics. The top-performing model will then be selected for iterative training and refinement. Feedback loops from annotation and quality control processes will be integrated to further improve performance. By the conclusion of Year 2, the trained Nurdle Count AI will be ready for deployment into the Nurdle Patrol website and mobile applications, providing a scalable solution for automated nurdle detection.



Task 4 - Integration with Nurdle Patrol: ***to be completed in year 2***

Initial design work began on the integration of Nurdle Count AI into the Nurdle Patrol Website (Design).

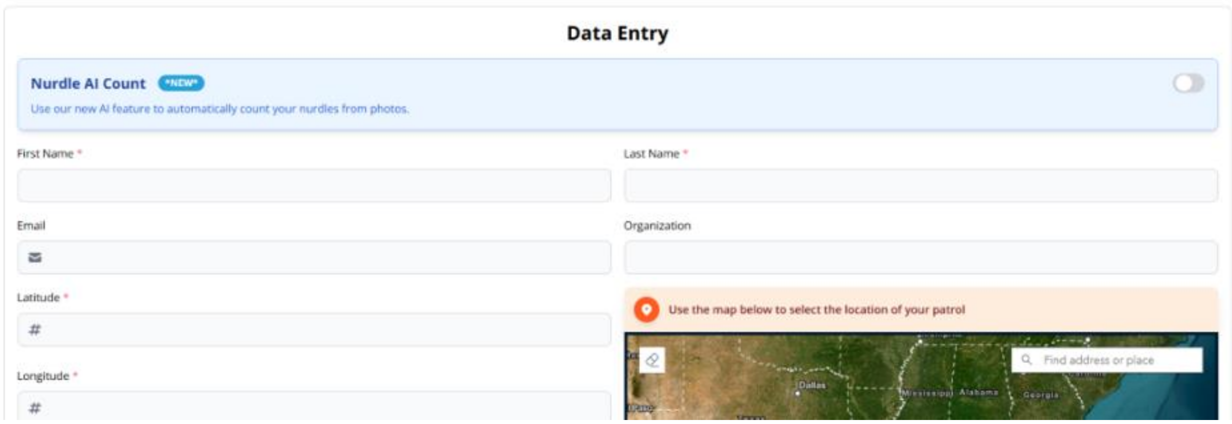


Figure 1:

The Data Entry form on the Nurdle Patrol Website will include a toggle to enable the Nurdle Count AI feature. If it is enabled, the actions below will follow:

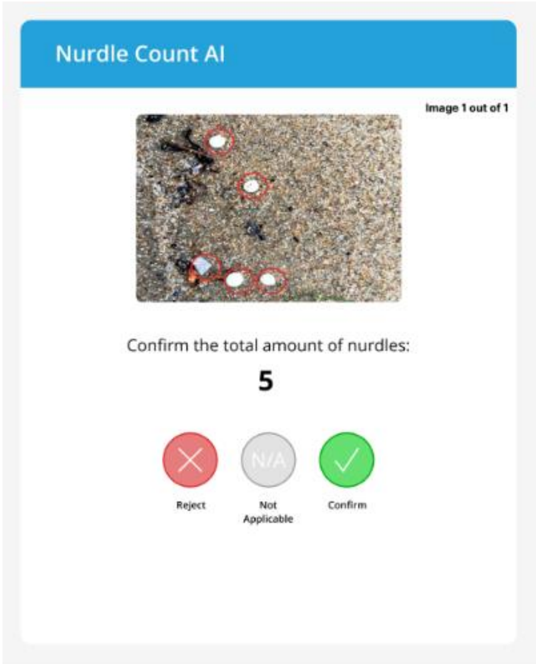


Figure 2: AI Detection & Confirmation

First, a pop-up will appear that uses Nurdle Count AI to automatically detect and estimate the total number of nurdles in the submitted image. The user will then be prompted to either confirm or reject the AI's detected count.

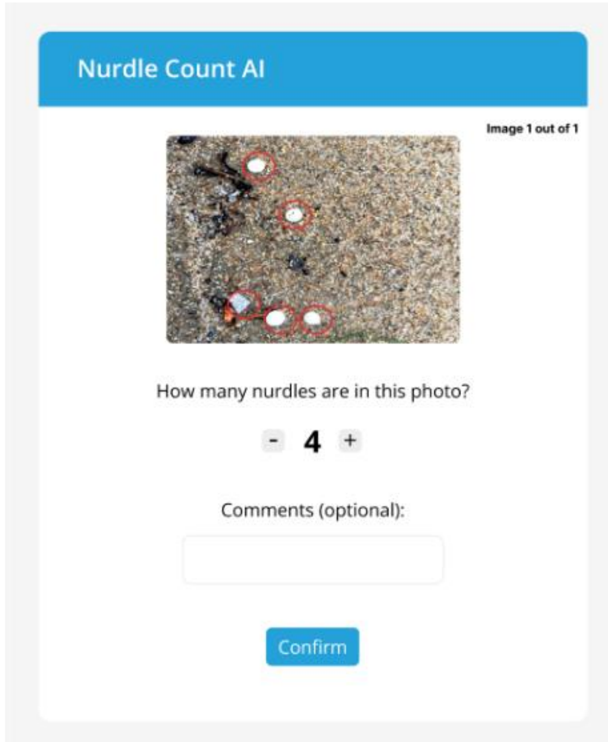


Figure 3: User Rejection & Manual Input

If the user rejects the AI's estimate, they will be asked to manually input the correct number of nurdles. An optional comment field will also be provided for additional notes or clarifications.

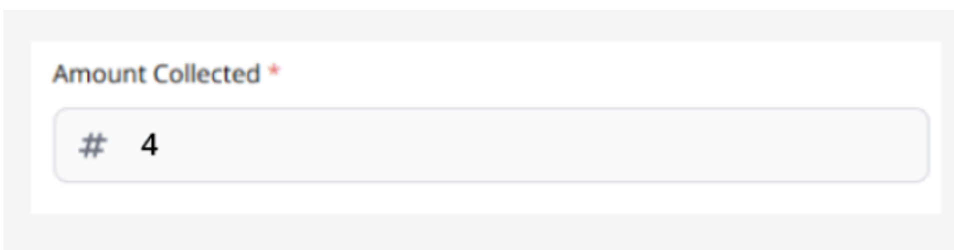


Figure 4: Form Auto-Population

Finally, once the user confirms, the form will be auto-populated.

Summary:

During Year 2, Tasks 3 and 4 will build on the foundation established in Year 1 to advance both model experimentation and platform integration.

For Task 3, the research team prepared a high-quality training dataset through the Nurdle Swipe tool, a web-based platform hosted on the Nurdle Patrol website. Using this system, 638 nurdle images collected under the image collection SOP were systematically reviewed. Of these, 545 were approved as qualified and 93 were disqualified due to issues such as reduced resolution, blurriness, excessive overlap, or lack of visible objects. The qualified images will form the core dataset for AI model training. Looking ahead, the team will conduct comparative testing across multiple computer vision architectures to evaluate precision, recall, and mean average precision (mAP). The top-performing model will then be selected for iterative refinement, supported by continuous feedback from annotation and quality control workflows. By the conclusion of Year 2, this trained AI will be ready for deployment.

Task 4 will focus on integrating the Nurdle Count AI into the Nurdle Patrol website. Initial design work has already established the framework for deployment. The integration centers on enhancing the existing data entry form with a toggle that allows users to activate the AI feature when submitting images. Once enabled, the system will generate a pop-up with the AI's automated nurdle count, prompting users to confirm or manually correct the estimate. An optional comment field will capture additional notes, and once confirmed, the form will auto-populate, streamlining reporting.

Together, these efforts ensure that the Nurdle Count AI is both accurate and accessible. Task 3 will deliver a rigorously trained model, while Task 4 will embed that model directly into the Nurdle Patrol platform. This combination of accuracy and usability marks a critical step toward scaling the project's impact, making automated nurdle detection available to citizen scientists and researchers across the Gulf of Mexico and beyond.

Synergistic Activities:

Over the summer of 2025, Jace Tunnell conducted a robust series of Nurdle Patrol outreach and education events across Texas and beyond, reaching a wide range of audiences from high school students to national organizations. These activities emphasized hands-on environmental education, citizen science engagement, and science communication.

Highlights include:

- 13 events delivered between May and July 2025, with a mix of in-person and virtual formats.
- Total reach of more than 520 participants**,** spanning K–12 students, teachers, community groups, scientists, and the general public.
- Local, regional, and national impact, with events hosted in the Texas Coastal Bend, at national venues such as NOAA and The James Museum in Florida, and through virtual sessions that connected with broader audiences.
- Educational themes focused on beachcombing, plastic pellet (nurdle) pollution, science communication, oysters and water quality, and the role of citizen science in coastal stewardship.

Notable engagements:

- A large-scale event with 150 students at Port Aransas ISD.
- A community partnership with the Corpus Christi chapter of the Daughters of the American Revolution (25 attendees).
- Virtual sessions with NOAA (87 participants) and Master Naturalists (55 participants), extending the program's reach nationally.

- An appearance at The James Museum in St. Petersburg, FL (50 attendees), introducing Nurdle Patrol to a broader geographic audience.
- Youth and family outreach at Del Mar's Youth Summit and Hurricane Alley Waterpark, reaching younger audiences in creative settings.

These events illustrate the strong demand for Nurdle Patrol's educational programming and the value of integrating science communication with citizen science opportunities. Collectively, this summer's outreach fostered environmental awareness, built community connections, and encouraged active participation in monitoring plastic pollution across coastal environments.

Here is a full list of events conducted during this reporting period:

Date	Organization	Type	Subject	Title	Location	Attendees
5/12/2025	Port Aransas ISD	In-person	Beachcombing/Nurdle Patrol	Beachcombing and NP the Coastal Bend Beaches	Port Aransas high school GYM	150
5/13/2025	Aquilla High School Aquatics Class	In-person	Beachcombing/Nurdle Patrol	Beachcombing and NP on San Jose Island	San Jose Island	9
5/16/2025	Corpus Christi chapter of the Daughters of the American Revolution	In-person	Beachcombing/Nurdle Patrol	Beachcombing the Gulf of Mexico	First Christian Church off Santa Fe	25
5/20/2025	CCME Paul Montagna group	In-person	Science communication	Science Communication and Engagement	HRI	40
5/22/2025	Master Naturalist Sabine	Virtual	Nurdle Patrol	Nurdle Patrol	Zoom	55
5/31/2025	Coastal Bend Bays Foundation	In-person	Beachcombing/Nurdle Patrol	Beachcombing and NP at Newport Pass	Newport Pass	20
6/3/2025	NOAA	Virtual	Nurdle Patrol	Plastic Pellet Research	Zoom	87
6/6/2025	The James Museum of Western and Wildlife Art	In-person	Nurdle Patrol	Nurdle Patrol Citizen Science Project	St Petersburg, FL	50
6/9/2025	Flour Bluff High School - Stephanie Huckabee Teacher Workshop	In-person	Nurdle Patrol and Beachcombing	Nurdle Patrol and Beachcombing	Flour Bluff High School	30
6/21/2025	Youth Summit at Del Mar	In-person	Plastics and Oysters	Oysters, Nurdles, and Water Quality	Del Mar CED	12
6/26/2025	Owen R. Hopkins Public Library	In-person	Beachcombing	Beachcombing Texas Beaches	3202 Mckinzie Rd	12
7/1/2025	Hurricane Alley Waterpark	In-person	Beachcombing/Nurdle Patrol	Booth	Hurricane Waterpark	80