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# AI-Powered Tracking for Sustainable Marine Ecosystem Resource Management Projects:

## A Case of Oyster Detection With Machine Learning

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## ABSTRACT

Ecosystems are our planet's life-support systems that facilitate sustainable development. Within the marine ecosystem, oysters serve as a keystone species. Numerous oyster restoration projects have been launched with a crucial element involving precise assessment of oyster population sizes within specific reef areas. However, the current methods of tracking oyster populations are approximate and lack precision. To address this research gap, the authors developed an AI-empowered project for oyster detection. Specifically, they created a dataset of wild oysters, utilized Roboflow for image annotation, and employed image augmentation techniques to augment the training data. Then, they fine-tuned a YOLOv8 computer vision object detection model using their dataset. The results demonstrated a mean average precision (mAP) of 85.2 percent and an accuracy of 87.7 percent for oyster detection. This approach improved upon previous attempts to detect wild oysters, offering a more effective solution for population assessment, which is a fundamental step toward sustainable oyster restoration project management.

## KEYWORDS

AI, Ecosystem, Machine Learning, Oyster, Sustainable Development

## INTRODUCTION

Sustainability and environmental awareness are of utmost importance in today's world (Alam & Islam, 2021; Severo et al., 2021). Climate change, habitat loss, pollution, and resource depletion are pressing issues that demand our attention. The health of our planet directly impacts our well-being, and we must strive to preserve and protect it for current and future generations. An increasing number of nations have been actively engaged in prioritizing sustainable development alongside economic growth (Cheng et

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al., 2022; He et al., 2022). Safeguarding the environment through sustainability encompasses targeted actions including the responsible stewardship of natural resources (Li et al., 2022; Sun et al., 2022), waste reduction (Sharma et al., 2020), mitigation of air pollution (Lin & Li, 2022; Yu et al., 2022), the preservation of biodiversity (Mittermeier et al., 2021), and the advancement of renewable energy utilization (Bui & Tseng, 2022; Zhu et al., 2022). These efforts collectively alleviate the negative impact of human activities on the environment, fostering an environmental self-regeneration and ensuring a sustainable future (Nunes et al., 2021; Uniyal et al., 2021; Zhou et al., 2022).

Ecosystems are the life-support systems of our planet, and they assume a fundamental role in achieving environmental sustainability (Arora & Mishra, 2019; Maes et al., 2019; Adla et al., 2022). These sophisticated networks, comprised of living organisms, their habitats, and the physical environments that they interact with, provide essential services supporting life on Earth (Cordier et al., 2021; Geary et al., 2020). Ecosystems control our climate, cleanse our air and water, pollinate the crops, and recycle vital nutrients (Fahad et al., 2022; Saha & Bauddh, 2020). They also offer essential territories for myriad species, boosting biodiversity (Davison et al., 2021; Swan et al., 2021). Furthermore, ecosystems offer essential resources, including provisions, pharmaceutical composites, and raw materials that contribute to human welfare and economic activities (Arroyo-Rodríguez et al., 2020; Pinho et al., 2021). Therefore, we must acknowledge the profound correlation between human activities and ecosystems to ensure sustainability. Safeguarding and revitalizing these natural ecosystems is not just a moral obligation, but it is also a vital requirement for our survival and the well-being of our planet (Dixson-Declève et al., 2022; Shrivastava & Zsolnai, 2022).

Within the living ecosystem of New York Harbor, oysters serve as a keystone species (Taillie et al., 2020). These remarkable filter feeders have the capacity to purify up to 50 gallons of water daily, significantly enhancing the water quality in the harbor (Everhart & Naundorf, 2021; Malik et al., 2023). Over the past decades, numerous oyster restoration projects have been launched, and they have been continually maintained and have managed to function to this day (Goelz et al., 2020; Pogoda et al., 2019; Ridlon et al., 2021; Wasson et al., 2020). The primary goal of these restoration projects is to rejuvenate the oyster populations in New York Harbor through the extensive creation and monitoring of oyster reefs. A crucial element of these restoration endeavors involves the precise assessment of oyster population sizes within specific reef areas (Hogan & Reidenbach, 2019; McClenachan et al., 2020). However, the current method of tracking oyster populations relies on estimates, and the counting techniques employed by existing oyster restoration projects lack precision (Zhu, 2023).

One of the key challenges in accurately counting oysters in a particular oyster reef is the limited availability of oyster detection models trained on wild oysters (Chand & Bollard, 2021). Most existing research papers in this field have primarily focused on training oyster detection models using computer-simulated oysters (Lin et al., 2022) or oysters from controlled farm environments (Sadrfaridpour et al., 2021). While these studies have provided valuable insights into oyster detection methodologies, the applicability of their findings to wild oyster populations in the New York Harbor remains uncertain.

In light of these limitations, there is an urgent demand for the creation of oyster detection models that are finely tuned to address the unique characteristics of wild oyster populations in the New York Harbor. Developing these models through the utilization of authentic data obtained from oyster reefs within the harbor promises to enhance the precision and dependability of oyster population evaluations. These advancements in oyster detection technology will yield benefits not only for the Billion Oyster Project (BOP) and similar oyster restoration initiatives but will also substantially contribute to our broader comprehension and preservation of oyster populations within estuarine ecosystems. To address this research gap, this paper develops and evaluates a novel oyster detection model using data collected from wild oyster reefs in the New York Harbor. By leveraging AI-empowered computer vision techniques and machine learning algorithms, we seek to enhance the accuracy of oyster population assessments and provide a more reliable method for monitoring oyster restoration efforts.

The paper is organized as follows. The next section reviews prior literature on the interconnections between sustainability and ecosystems and summarizes relevant research on oyster detection. The

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