Optics Strategic Initiative (OSI):
Smaller, Cheaper, Smarter, and Accessible Optical Solutions

OSI Team:
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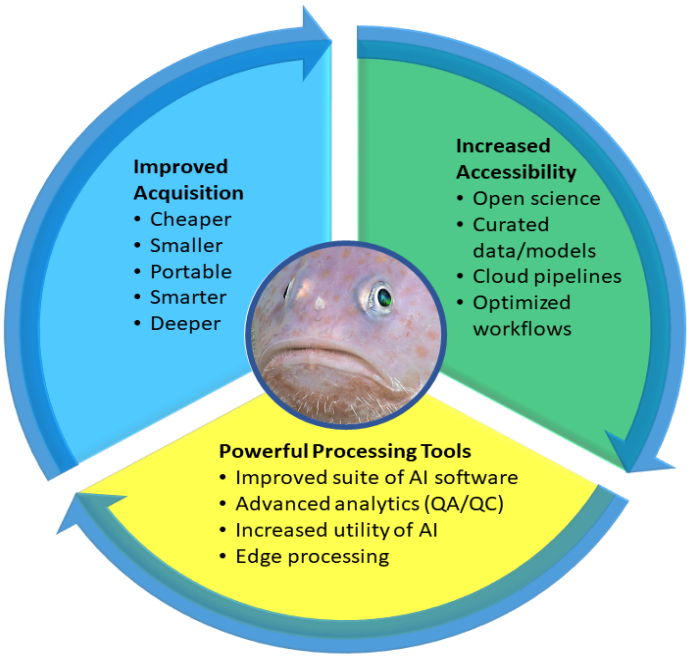
Summary Statement: The Optics Strategic Initiative (OSI) will make significant investments to transform NMFS's approach to optical data collection and processing. In so doing, OSI will operationalize large-scale image collection, storage, and processing; complement, optimize, and replace existing ship- and aircraft-based surveys, automate and optimize data processing pipelines, and provide novel, mission-improving metrics. Specifically, OSI will fund projects to improve access to optical survey and analysis tools, including investments in low-cost acquisition hardware, edge AI bearing payloads and UxS platforms, machine learning assisted image processing pipelines, and hybrid cloud processing capacity. Priorities include expanding and optimizing broadly applicable platforms and tools, especially those that enhance capabilities for data-poor regions and emerging missions. We envision developing a suite of transformational technologies that enable end-to-end automation of optical sampling methods.



Background: Optical imagery increasingly serves as the primary data source for many existing NOAA surveys (e.g. Fishery-independent surveys and electronic monitoring) which directly support Natural Resource Management, Sustainable Fisheries, Ecosystem-Based Fishery Management, the New Blue Economy, and a Climate Ready Nation. Optimized optical technology is critical for efforts to move away from traditional ship-based and visual aerial survey methods and towards uncrewed systems and platform agnostic data collections. Recent efforts such as the Advanced Sampling Technology Working Group (ASTWG) catalyzed significant advancements in optical and acoustic sampling platforms while the Automated Image Analysis (AIASI) and the Untrawlable Habitat (UHSI) strategic initiatives made significant progress addressing foundational aspects of using optics and which this Optical SI will build upon. For instance, several developments from the earlier SI's have become valuable tools for NOAA analysts such as ML/DL based analysis and performance evaluation (e.g. VIAME and CoralNET). While useful in their current state, these tools would benefit from modernization, improved user interfaces, cloud deployment, and continued integration of the constantly evolving set of tools and algorithms developed by the computer science industry. Automation will be critical as the availability of days at sea (DAS) aboard NOAA Fishery Survey Vessels (FSV) is decreasing and recent initiatives to begin collecting data in otherwise inaccessible locations (e.g. wind lease areas) heighten the importance of a transition to platform-agnostic data collections. With increasing application of optical data collection platforms and scalable automated processing solutions, the volume and utility of optical data sets is increasing exponentially. To address this issue several science centers have created transition plans to move automated processes into operations. Realization of end-to-end

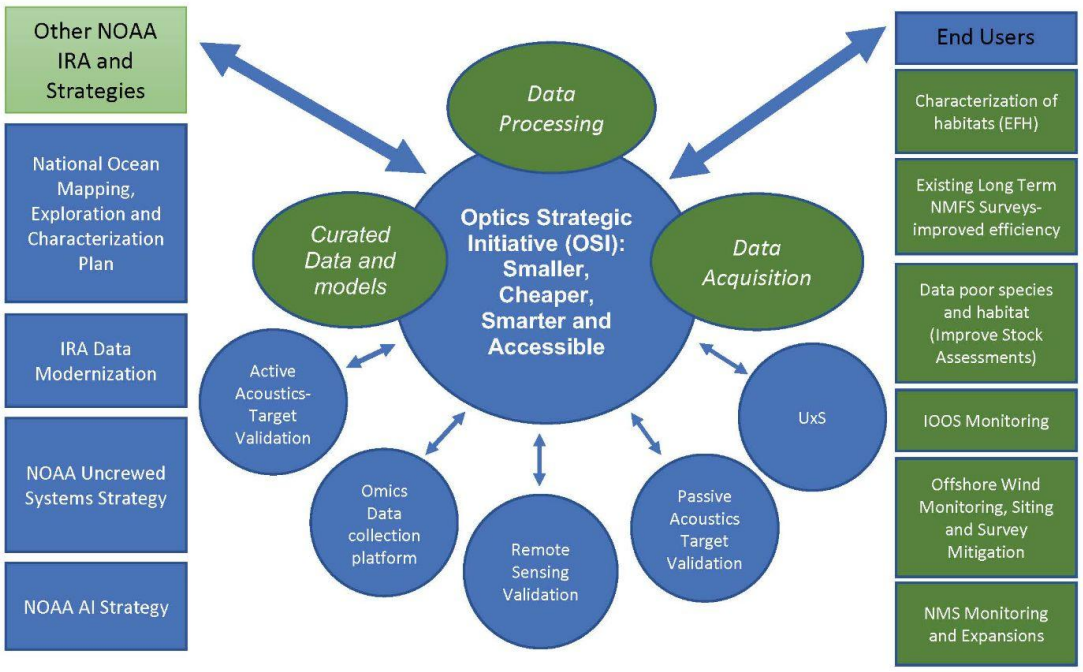
automation of optical data processing is contingent upon components highlighted in this vision document to be resolved, in particular data management and processing speed. Significant investment is needed to make them efficient, accessible, and relevant for resource management (e.g. stock assessment).

Vision goals: Our vision for the Optics Strategic Initiative (OSI) is to foster a transformative shift in the National Marine Fisheries Service's (NMFS) approach to optical data collection and processing, reshaping the landscape of resource management and environmental stewardship. We aim to catalyze the transition from traditional ship-based and aerial surveys to platform-agnostic, scalable automated systems, thereby enriching the value and applicability of optics. This journey involves investment in the development of low-cost acquisition hardware, AI-bearing payloads and Uncrewed Systems (UxS), machine learning-assisted image processing, and hybrid cloud processing. Striving to equalize access to these tools across diverse regions, our endeavor is to establish efficient, accessible, and smart optical data acquisition and analysis pipelines, capable of swiftly transforming vast volumes of data into accurate, management-relevant products. In a world grappling with climate change and resource scarcity, the OSI stands at the forefront of NOAA's commitment to a resilient Blue Economy and a Climate Ready Nation.

- ***Improved Data Acquisition***
    - Platform-agnostic optical systems
        - Devices to enable collection of imagery from a variety of platforms.
        - Integration with existing UxS platforms that serve as force multipliers capable of providing coverage in places and times that ships cannot.
        - Low-cost, small optical devices and platforms that can be deployed across a wide region, particularly for resource limited regions.
        - Commercialization to catalyze reduced cost and industry support for continued maintenance and long term support.
    - Establish data sources for undersampled or data-poor areas/regions.
        - Leverage developments in platform-agnostic systems.
        - UxS, ship- and aircraft-based systems for ecosystem monitoring and satellite validation.
            - High resolution aerial imaging to expand survey range to data-poor areas.
            - IFCB, LISST, ACS, holographic imagers.
            - Provides absorption properties, particle size, and species composition.
- ***Powerful Processing Tools***
    - Modernize automated image analysis software to facilitate increased efficiency in data processing, analytical accuracy, and increased capacity and deployment of optics.
        - Improve existing processing tools (e.g. VIAME, CoralNET, Tator, Metashape, TagLab, NemoNet, etc).
        - Ensure that tools handle imagery and data/calibration formats of all Centers.
        - Incorporate new algorithms, architecture, and methods (e.g. queried learning).
        - Embedded AI/ML and edge-computing capabilities for optical systems.
    - Cloud-based deployment of data reduction, processing, and analysis frameworks.
        - Enterprise level, scalable GPU to reduce duplication of on premises resources to increase efficiency and create centralized data pipelines.
- ***Increased Accessibility***
    - Develop world-leading classifiers, detectors and trackers, and segmentation models for fish, plankton, benthic ecosystems, marine mammals, birds, otoliths, and more.
    - Organize, make accessible, and label NOAA’s many optical image data sources.
    - Develop and host training datasets, functional code, and GUI-based processing steps that demonstrate proof of concept for users, and facilitate customizing models.

- Create/expand user groups and rotational assignments for improved analyst and developer skill and knowledge transfer.

Linkages to other SIs: Our OSI vision is integral to the other NMFS Strategic Initiatives, and through organic and strategic coordination, we can transform our data collection methods to meet the ever-changing needs of climate-ready fisheries. Optical imagery is essential to, and has been integrated with, a wide variety of other data sources including remote sensed satellite validation, the identification of acoustic targets, and the interpretation and validation of eDNA targets. Uncrewed systems are at the nexus of our vision for smaller/deeper/cheaper/smarter and platform-agnostic optical sensors, and data modernization is paramount to the success of moving from data acquisition to data delivery.



Vision end-point:

How will the *Optical Strategic Initiative* have transformed the optical landscape at the end of 4 years?

OSI envisions a transformative suite of products that enable end-to-end automation of optical sampling from acquisition to analysis. The creation of fully integrated hardware-to-software optical data pipelines, embedded into onboard processing systems of UxS where possible, will meaningfully reshape the NMFS monitoring enterprise, improving efficiency, flexibility, and data quality.

We will demonstrate that end-to-end automated approaches to optical sampling can reduce survey days and hands-on processing time, while increasing our temporal coverage and spatial range of data acquisition, diversity of targets, and quality of management-relevant metrics. This transformation will reduce our reliance on white-ships, diversify our portfolio of sampling strategies, and avail monitoring technology to under-served regions.