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Bren School of Environmental
Science & Management

*Assessing The Cost Effectiveness of Various Approaches to Detecting
and Combating Illegal, Unreported, and Unregulated Fishing for the
Philanthropy Sector*



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Client: Skylight, Allen Institute for Artificial Intelligence

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OBJECTIVES

This project will support the work of the Skylight team, based out of the Allen Institute for Artificial Intelligence (Ai2), in their mission to deliver meaningful impacts towards reducing illegal, unreported, and unregulated fishing (IUUF). Specifically, Ai2 is interested in understanding the most cost-effective approaches for monitoring IUUF and subsequent enforcement in the Pacific Islands. This will be achieved through the following objectives:

1. *Develop a comprehensive comparison of various IUUF monitoring and enforcement measures in the Pacific Islands, including technology- and policy-based mechanisms*
2. *Define cost-effectiveness for IUUF monitoring and enforcement and develop a cost-effectiveness tool to be utilized by Skylight and partners in the Pacific Islands*
3. *Synthesize findings into a set of recommendations for cost-effective IUUF prevention solutions for the NGO and philanthropic community invested in the health of Pacific Islands fisheries and communities*

SIGNIFICANCE

IUUF involves many illicit behaviors including local fishers catching more than their quotas allow, foreign vessels fishing illegally in another nation's sovereign waters, and criminal networks that are often linked to drugs, arms, and human trafficking as well as piracy and terrorism (Shaver and Yozell, 2018). IUUF is a global ecological and maritime security threat that is directly connected to the global decline in fish stocks due to increased demand for seafood products (Shaver and Yozell, 2018). Ai2 (2022) states IUUF is "an economic, human rights and food security issue that impacts billions of dollars and millions of people globally and is a key driver of ocean health decline." The Food and Agriculture Organization of the United Nations (UNFAO) estimates that almost 90 percent of the world's fisheries are being exploited or have been depleted, while the global demand for seafood products continues to increase. IUUF has emerged as a result of this demand, and research suggests that IUUF is double the amount of reported fishing activity, with an annual profit of \$15.5 to \$36.4 billion annually (Shaver and Yozell, 2018).

IUUF further depletes global fish stocks, which in turn impacts the health of marine ecosystems and the flora and fauna (humans included) who depend on these systems for survival. In addition to these ecological impacts, IUUF is also considered a threat to economic and food security, maritime security, and geopolitical stability on national, regional, and global scales (Shaver and Yozell, 2018). IUUF disproportionately affects coastal countries in under-resourced regions that do not have the capacity or resources to effectively monitor and enforce fishing activities. The Pacific Islands region, especially, is an area where available resources for combating IUUF are most limited and the maritime areas these resources would benefit is largest (Kolla, personal communication, Jan. 12, 2023).

Skylight uses artificial intelligence and remote sensing to identify vessels that may be participating in IUUF or related maritime crimes (Ai2, 2022), which was identified in a recent study by a number of international maritime agents as one of the most effective approaches to combat IUUF (Burroughs and Mazurek, 2019). Ai2 covers the costs of developing and providing the tool and its data for free to coastal state governments. However, there continue to be limitations to how much remote sensing-based technology can effectively monitor and enforce against IUUF alone (Ai2, 2022). The limitations are particularly stark in relatively low-resourced regions like the Pacific Islands. Ai2 is keen to better understand the cost-effectiveness of applying tools like Skylight compared to / in complement to other ways of monitoring and enforcing against IUUF. This project aims to support Ai2 and its partners with a shared mission of reducing IUUF in evaluating the cost-effectiveness of various approaches for combating IUUF and to evaluate specifically how investments in remote sensing-based tools like Skylight fit in.

BACKGROUND

IUUF in the Pacific Islands is widespread and threatens national security for many island nations. Due to the archipelago nature of many Pacific nations and the maritime law that designates 200 nautical miles from a nation’s shore as its Exclusive Economic Zone (EEZ), Pacific Island nations have outsized national waters to protect compared with other regions (Figure 1, see Appendix). Palau, for example, has a total of 189 square miles of land but 237,850 square miles of EEZ. With very small populations, these nations do not have the resources to patrol their waters to the extent needed to prevent IUUF and struggle to take action against perpetrators when they are identified.

Skylight works with partners such as WildAid and the United Nations Office on Drugs and Global Maritime Crime Programme to contribute on-the-ground resources in coastal countries most threatened by IUUF. Skylight AI technology automatically analyzes millions of incoming data points to detect highly suspect events rather than showing a “spaghetti bowl” of vessel tracks. Harnessing these data, Skylight generates Automatic Identification System (AIS)-based alerts in areas of interest that are shared in real-time with end-users. Skylight also helps enable maritime law enforcement by: (1) Identifying incursions by commercial fishing vessels in or near Marine Protected Areas (2) Highlighting where transshipments of fish or other goods may be occurring especially near or in a country's Exclusive Economic Zones (3) Tracking networks and enablers of illegal activity, such as vessels who bunker (re-fuel) other illegal fishing vessels. Ai2 would like to understand how the Skylight annual operating budget compares with other monitoring and enforcement measures. Table 1 summarizes a non-exhaustive list of various IUUF monitoring and enforcement methods to be evaluated.

Table 1. IUUF Monitoring and Enforcement Methods

Monitoring	Enforcement
<ul style="list-style-type: none">● Remote sensing● Vessel patrols● Plane patrols● Drone patrols● Crowdsourcing observations	<ul style="list-style-type: none">● Sending a plane● Sending a vessel● Sending a drone● Port-based actions● Flag-based actions● Ownership based actions● Customs/taxation● Investigative journalism and public awareness

In the IUUF prevention space, there is no recognized measure of cost-effectiveness across the various monitoring and enforcement methods. The project team will develop a methodology to compare the effectiveness of the above methods and AI technology supported methods. Measures of effectiveness could include the number of illegal incursions detected or arrests made over a given time period.

EQUITY

IUUF is not only a major environmental concern, but also a human rights issue. Many of the fishers aboard IUUF boats are desperate for work and are severely mistreated. There are untold counts of sea slavery, physical and sexual abuse, and unpaid wages on boats that are also responsible for IUUF. The lack of regulations and the difficulty of enforcing existing regulations have led to some calling the ocean ‘the world’s biggest crime scene’. While there are many factors that contribute to human rights abuses that take place at sea, a better utilization of existing tools (national and international maritime laws, regulations, and enforcement mechanisms, technology), can help reign in rampant IUUF. Skylight is provided at no-cost to government agencies who share its mission to detect and deter IUUF. The platform strives to be as accessible as possible by not requiring any specialized hardware (the application is available through a simple and secure web-based login) and being available in multiple languages.

AVAILABLE DATA

- National Wikipedia pages are a good resource for compiling the physical assets of countries available for maritime enforcement. For example, [Palau](#) is listed to have “two long-range patrol boats, the Kedam and the Remeliik II, to hunt for poachers and unlicensed fishermen”. This information will be important in understanding what resources are available to Pacific nations.
- The [Spyglass](#) database is an important resource for fishing vessels’ criminal records.
- Many remote sensing data sources for identifying vessels are publicly available such as [Visible Infrared Imaging Radiometer Suite](#) (VIIRS) and [Synthetic Aperture Radar](#) (SAR). Additionally, signal data sources such as [Automatic Identification System \(AIS\)](#) or [Radio Frequency \(RF\) detection systems](#) can be used to track vessels but require payment to use the tracking systems. See the Appendix for a summary of vessel detection data sources, created by Skylight.
- [Global Fishing Watch](#) provides data that can be used to conduct historical analyses, such as how fishing effort levels have changed after the creation of specific Marine Protected Areas or the implementation of new laws or port measures.

POSSIBLE APPROACHES AND DELIVERABLES

Table 2 details a proposed scope of work, including project tasks and deliverables.

Table 2. Scope of Work

Task	Description	Deliverables
Develop project work plan	Conduct a literature review on past and present IUUF monitoring and enforcement work in the Pacific Islands. Use knowledge gained to refine project scope and develop project work plan.	Project work plan
IUUF monitoring comparison IUUF enforcement comparison	Research all known IUUF monitoring methods and enforcement mechanisms relevant to the Pacific Islands. Compare the effectiveness of different approaches in the region.	Memo suitable for Skylight to share with partners
Define IUUF monitoring cost-effectiveness Define IUUF enforcement cost-effectiveness	Synthesize findings from IUUF research to define cost-effectiveness for both monitoring methods and enforcement mechanisms. Aim is to answer the question: how do we measure the success of a given monitoring or enforcement approach?	Report that summarizes the methods and foundations of the cost-effectiveness measure.
Develop IUUF monitoring and enforcement cost-effectiveness tool	Develop a tool that allows users to input specific resource allocation parameters and outputs the cost-effectiveness of various monitoring and enforcement approaches, including those supported by AI.	Cost-effectiveness tool suitable for Skylight partner use.
Final report and presentation	Final report that summarizes work completed, knowledge gained, research methods, and project outcomes.	Final report and presentation to Skylight team.

INTERNSHIP

The Skylight team is seeking to host a paid internship for the summer of 2023 to support a grant to aid in the detection and interdiction of IUU fishing. See the Client Letter of Support for more details.

SUPPORTING MATERIALS:

CITATIONS

Allen Institute for Artificial Intelligence. (2022). “Improving maritime transparency to protect our oceans.” Accessed on 01/16/23 from <https://www.skylight.global>

Burroughs, L. and Mazurek, R. (2019).”Maritime Security in the Indian Ocean: Perceived Threats, Impacts, and Solutions.” *Caught Red-Handed Brief - One Earth Future*, 8 pp.
https://safety4sea.com/wp-content/uploads/2019/07/One-earth-futureSecure-fisheriesUNODC-Maritime-security-in-the-Indian-ocean-2019_07.pdf

Foster, S. (2022). “Pacific Islands.” *Encyclopedia Britannica*. Accessed on 01/16/23 from <https://www.britannica.com/place/Pacific-Islands>

Shaver, A. and Yozell, S. (2018). “Casting a Wider Net: The Security Implications of Illegal, Unreported, and Unregulated Fishing.” *The Stimson Center*, 38 pp.
https://oursharedseas.com/wp-content/uploads/2019/11/Stimson_2018_Casting-a-Wider-Net-Report.pdf

WHO. (2013). “Pacific Island Countries.” *Country Cooperation Strategy Brief*, 2 pp.
https://apps.who.int/iris/bitstream/handle/10665/136831/ccsbrief_pci_en.pdf?sequence=1&isAllowed=y

BUDGET AND JUSTIFICATION

This project should not need funding beyond the given \$1,300 from the Bren School.

January 27, 2023

Bren School of Environmental Science & Management
UC Santa Barbara
Santa Barbara, CA 93106-5131

Dear Bren School Group Project Coordinators:

It is my pleasure to write a letter in support of the Group Project Proposal being submitted to the Bren School Program by Eleri Griffiths and Eleanor Thomas. This proposal would support the work of the Skylight team, based out of the Allen Institute for Artificial Intelligence (Ai2). Skylight's mission is to:

Deliver meaningful impact towards reducing illegal, unreported, and unregulated fishing (IUUF) by applying advanced analytics, including state-of-the-art AI, to a combination of data sources that enables analysts to support enforcement and compliance action, and contribute to creating transparency in the fisheries and maritime domain.

We are grateful to have an opportunity for brilliant graduate students at the Bren School to work on helping the Skylight team assess the role technology has to play in enabling IUUF enforcement, particularly for developing states. Specifically, this project would provide an important cost-benefit analysis of different artificial intelligence tools used for IUUF monitoring and enforcement, and recommend cost-effective IUUF prevention solutions for under-resourced countries. From the project team's assessment, Ai2 will be able to make better decisions about where philanthropic funds are spent to address IUUF and how Skylight fits into the bigger picture. As the client of this project, we are committed to providing consultation and relevant data through the entire duration of the project.

In addition, the Skylight team is seeking to host a paid internship for the summer of 2023 to support a grant to aid in the detection and interdiction of IUU fishing. The internship would deep-dive into some of the proposed tools for IUUF monitoring and enforcement - autonomous underwater and surface vehicles, cameras and hydroacoustic arrays - which should feed into the broader cost-effective analysis for various IUUF prevention solutions. The internship is not confirmed as funding is still in the works. Our team will update the Bren School no later than March 31, 2023. If you need additional information, please do not hesitate to reach out.

Sincerely,



Namrata Kolla
Product Manager, Skylight
Allen Institute for Artificial Intelligence (Ai2)

APPENDIX

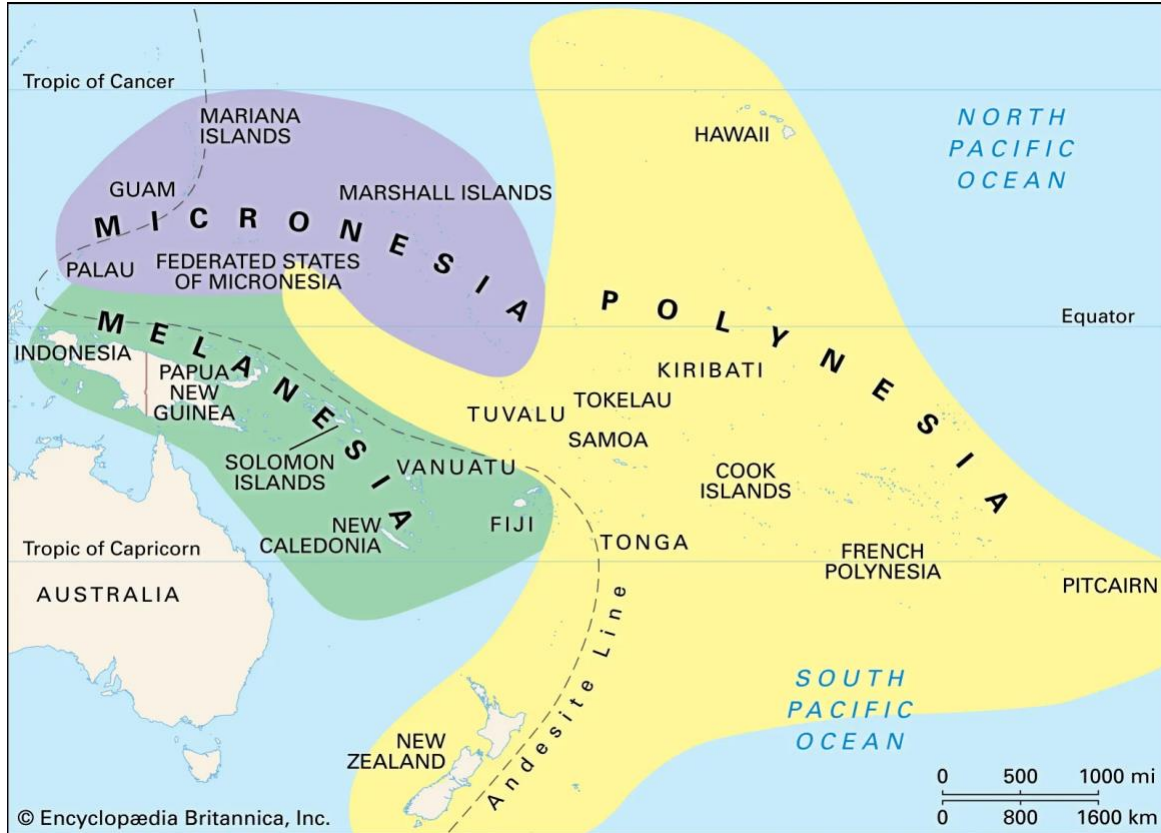


Figure 1. Map of the Pacific Island Region (Foster, 2022), which includes the ethnographic groupings of Melanesia, Micronesia, and Polynesia, and the nations of the Northern Mariana Islands, the Federated States of Micronesia, Fiji, French Polynesia, Kiribati, the Marshall Islands, Nauru, New Caledonia, New Zealand, Palau, Solomon Islands, Tonga, Tuvalu, Vanuatu, and Wallis and Futuna (WHO, 2013), but conventionally excludes Australia, as well as the Indonesian, Philippine, and Japanese archipelagos (Foster, 2022). *Source:* <https://www.britannica.com/place/Pacific-Islands>

Current Skylight users in the Pacific:

- Australian Fisheries Management Authority (AFMA)
- Cook Islands Police
- Federated States of Micronesia Fusion Centre
- Fiji Maritime Search and Rescue Coordination Centre (FMSRCC)
- French Polynesia Fusion Centre
- Kiribati Police
- Nauru Police
- Niue Customs
- Pacific Islands Forum Fisheries Agency (FFA)
- Palau Marine Law Enforcement Group
- Pitcairn Islands Administrator
- Samoa Police
- Tonga Navy
- Tuvalu Police

SIGNAL

	<i>BENEFITS</i>	<i>LIMITATIONS</i>	<i>LEARNINGS</i>	<i>UPDATES</i>
AIS	<ul style="list-style-type: none"> Track data Frequent global coverage. Commercially available. Industry standard source of intelligence. Near-real time 	<ul style="list-style-type: none"> Signal can easily be shut off. Global, near-real time coverage is expensive. 	<ul style="list-style-type: none"> AIS has limited relevance to non-commercial fishing and can easily be turned off if a vessel wants to avoid being monitored when engaging in illicit activity. 	<ul style="list-style-type: none"> AIS gap / lost transition alerts are under development. Transition to Spire from Orbcomm has addressed some issues around pricing / scaling.
VMS	<ul style="list-style-type: none"> Track data Required for many fishing vessels across the globe. Near-real time. 	<ul style="list-style-type: none"> Data are confidential and challenging to access due to government restrictions. Our algorithms generally require higher transmission frequency than VMS provides. 	<ul style="list-style-type: none"> The political effort necessary to gain access is not scalable. 	<ul style="list-style-type: none"> API access may address the privacy issue by allowing users to layer our data within their systems.
RF	<ul style="list-style-type: none"> Broad coverage of vessels not transmitting AIS, aka “dark vessels” Near-real time. 	<ul style="list-style-type: none"> Constellation not yet complete, which limits revisit rates. Limited geolocation accuracy. 	<ul style="list-style-type: none"> RF may be more cost effective than SAR for detecting dark vessels at scale Accuracy still needs evaluation 	<ul style="list-style-type: none"> Working with Pew to set up a pilot project evaluating HE360 data over a yet-to-be-determined fishing ground.
SAR	<ul style="list-style-type: none"> Imagery Detects dark vessels Broad coverage. Automated vessel detection & AIS correlation. 	<ul style="list-style-type: none"> Data delay is significant (>6hrs). Decreasing latency is an additional cost Collections must be planned. Low resolution. Provides limited vessel information (heading, length) and does not detect small vessels. 	<ul style="list-style-type: none"> SAR supplements AIS offering by providing intelligence on areas with dark activity and demonstrated its value in Ghana, but its infrequent refresh and long delay limit its usability. 	<ul style="list-style-type: none"> Evaluating the usability of free SAR to fill the situational awareness use cases, allowing us to focus lower latency, higher resolution paid collections on operational areas.
EO	<ul style="list-style-type: none"> Imagery Detects dark vessels High resolution may allow for vessel ID. Automated vessel detection & AIS correlation. 	<ul style="list-style-type: none"> Small satellite footprint means that collections must be targeted. Targeting requires a ‘tip’ from another data source to ‘queue’ the EO satellite. Cloud cover is a challenge, particularly at sea. 	<ul style="list-style-type: none"> EO is expensive and still not quite ready for operationalization due to the limited constellation size. No viable tipping data source at present, though RF holds promise 	<ul style="list-style-type: none"> Tip / cue case study is now on hold as we evaluate long-term satellite strategy.
VIIRS	<ul style="list-style-type: none"> Detects vessels at night using large lights (such as with squid fishing) Free data. 	<ul style="list-style-type: none"> Vessel detection is not part of the free data set. Only detects certain types of fishing. Intermittent coverage. 	<ul style="list-style-type: none"> Possible to process, correlate, and display data in a manner similar to SAR 	<ul style="list-style-type: none"> Still in exploration phase.

IMAGERY

Active Global Engagements

Latin America

- National Centers: Royal Bahamas Defense Force (RBDF), Colombian Armada (ARC), Dominican Republic Navy, Ecuador Directorate of Aquatic Spaces (DIRNEA), Jamaican Defence Force
- Parks/NGOs: Revillagigedo NP (Mexico), Malpelo NP (Colombia)

West and Central Africa

- Regional Centers: CRESMAO, MMCC Zone E, MMCC Zone F
- National Centers: Cabo Verde Coast Guard; Côte d'Ivoire Navy; Ghana Navy; Gabon Navy; Liberian Coast Guard; Nigerian Maritime Authority; Sao Tome and Principe Coast Guard and Fisheries
- Parks: Gabonese Agency for National Parks

Indian Ocean

- Regional Centers: Operations and Information Fusion Centers (RCOC, RMIFC)
- National Centers: Comoros Coast Guard; Kenya Coast Guard; Madagascar NMIFC; Maldives Coast Guard, Fisheries; Mauritius Coast Guard, Customs, Fisheries; Mozambique Navy, Police; Seychelles NISCC; Somalia Fisheries; Sri Lanka Navy
- Parks: Bazaruto National Park (managed by African Parks)

Southeast Asia

- National Centers: Indonesian Maritime Security Agency; Malaysian Coast Guard; Philippines National Coast Watch Center; Thailand Office of Narcotics Control; Timor Leste Navy; Vietnam Directorate of Fisheries, Search & Rescue Coordination Centre

Pacific

- Regional Centers: Pacific Islands Forum Fisheries Agency (FFA)
- National Centers: Australian Fisheries Management Authority; Cook Islands Police; Federated States of Micronesia Fusion Centre; Fiji Maritime Search and Rescue Coordination Center (FMSRCC); French Polynesia Fusion Centre; Kiribati Police; Nauru Police; Niue Customs; Palau Marine Law Enforcement; Pitcairn Islands Administrator; Samoa Police; Tonga Navy; Tuvalu Police
- Parks/NGOs: OceanMind (in Palau); Phoenix Islands Protected Area Implementation Office

40+ Active Country Engagements

5+ Regional Organizations

