Tun-AI

Using echosounder buoy technology to study tuna behaviour at sea

- 36% of global tropical tuna catch relies on dFADs – drifting fish aggregating devices used by tuna purse seine fleets across all major oceans.
- These dFADs are equipped with high tech echosounder buoys that remotely provide information on tuna abundance and location.
- Spanish researchers have developed Tun-AI, an AI tool that processes information from these buoys to improve knowledge on tuna ecology.
- Tun-AI combines dFAD echosounder buoy data, remote-sensing data, and catch statistics for uniquely accurate biomass predictions.
- The project represents a unique collaboration between researchers, the fishing industry, and the technology sector in favour of scientific research.

For centuries, fishing communities have known that some species of fish gather around floating objects drifting on the surface of the ocean, including tropical tuna such as skipjack, yellowfin, and bigeye. Today, manmade floating objects called drifting fish aggregating devices (dFADs), often equipped with high tech echosounder buoys, have become an essential tool for the fishing industry, accounting for up to 36% of global tuna catches. These echosounder buoys, deployed across tropical oceans, are coupled with GPS and satellite communications, and report their location at least once a day. They also contain an echosounder with which they can periodically sample the water column beneath them for biomass, primarily tuna and other species of fish. This information is not only enormously helpful for the fishing industry to increase fishing efficiency and reduce operation costs and carbon emissions, but also proves useful for the scientific community.

Each dFAD, equipped with its echosounder buoy, can be considered a floating sampling station, as it consistently relays information on position and presence or absence of fish biomass underneath it. Over time, the data provided by these buoys can give insights into how fish behave at sea or shed light on the health and status of tuna stocks. Since tuna is a highly migratory species, traditional methods of studying its ecology are expensive and highly localised. Instead, collaborating with the fishing industry and using the information provided by dFADs and their echosounder buoys can take the study of these species to a new level in a cheap and highly effective way.

> **The use of dFADs and high-tech echosounder buoys is widespread across tropical oceans, and processed data from these buoys can be highly relevant for the scientific community.**

To achieve this, Satlink partnered with a team of researchers at Komorebi AI, in collaboration with the University of Cádiz and University Carlos III, Spain, to develop a unique tool – Tun-AI, which processes the echosounder information provided by the buoys attached to dFADs, to give accurate estimates of the size of tuna aggregations around a given dFAD. This tool will allow scientists to use the biomass estimates collected by dFAD buoys to better understand the biology and behaviour of tuna species around the world.

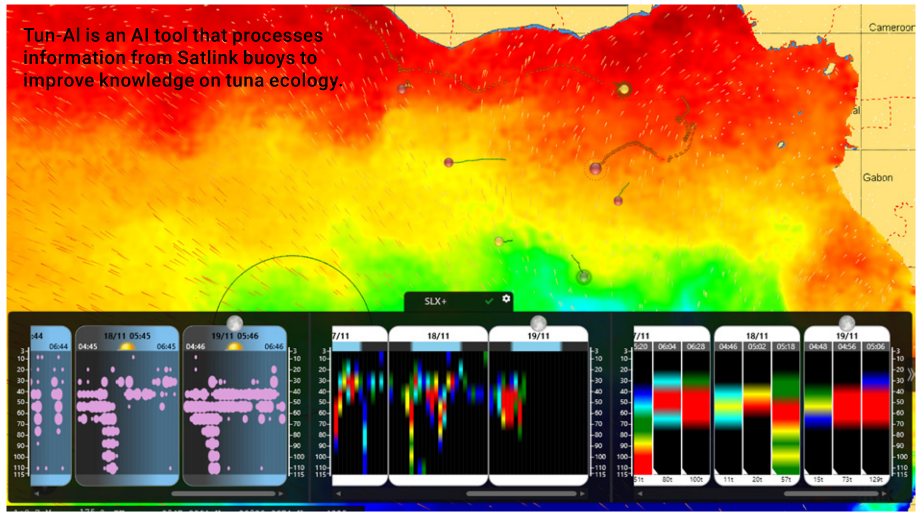
Artificial intelligence and machine learning

Tun-AI uses a collection of machine learning models to estimate the tuna biomass under any given buoy at any given time. To train this artificial intelligence (AI) tool, the researchers have used data from the satellite-linked echosounder buoys attached to dFADs and combined it with remote-sensing biological and oceanographic data, such as information about ocean currents, water temperature, and presence of phytoplankton. To ground truth the information provided by the buoys, and further increase the reliability of estimation, the tool was trained on ten years of catch data provided by the fishing industry.

In tests, Tun-AI achieved above 92% accuracy when distinguishing between the presence or absence of tuna under a dFAD (with a threshold of ten tons). When compared against real-world measurements – and confirmed in the field – the tool had an average relative error of 28% when estimating the amount of tuna below the buoy. Because it identifies tuna biomass so accurately, distinguishing it from other fish species that may be present under the buoy, Tun-AI can also help fishing vessels reduce bycatch of less commercially relevant species – a great step forward in further increasing the selectivity of this fishing gear. When compared to human experts completing the same tasks, Tun-AI actually outperformed its counterparts, achieving reliable estimates of tuna biomass in an automated way. This performance and ease of use makes Tun-AI a powerful tool for researchers looking to make the most out of

Echosounder buoy information can be used for efficient and sustainable fishing, and furthering knowledge about the ocean environment.

Each Satlink echosounder buoy relays information on position and presence or absence of fish biomass underneath.



Tun-AI is an AI tool that processes information from Satlink buoys to improve knowledge on tuna ecology.

information provided by dFAD buoys, and several scientific bodies are already making use of similar models to assess tuna populations' health over time.

Tun-AI for scientific research

The reasons driving tuna's tendency to aggregate around floating objects are still largely unknown, and have been the source of much debate both within the industry and the scientific community. However, given the extent of dFAD use and the massive amount of information provided by the echosounder buoys, the researchers believe Tun-AI can provide insight on a scale that would be impossible using traditional methods of study.

> **Through cross-sector collaboration, Tun-AI offers the scientific community access to robust and continuous data that can enable the study of tuna species worldwide, in a cost-effective way.**

For this new study, the team used Tun-AI on four years of data from 16,000 buoys deployed around the world's oceans to characterise the temporal dynamics of tuna aggregations around dFADs. This included using the estimates provide by Tun-AI to track the time it took for tuna to start aggregating around a dFAD, and to look at how long that aggregation would remain. Both times vary depending on the ocean basin, but time for the aggregation to form was estimated at around a month, and the amount of time it remained at the dFAD was a median of 10 days. Nonetheless, considerable variation was found among samples, highlighting the importance of using large amounts of data rather than localised studies, as had been done until today.

The future of tracking tuna

Through this multi-sector study, involving technology provider Satlink, Komorebi AI, the fishing industry, and the scientific community, Gómez-Ullate and his team have paved the way for echosounder buoy information to be used not only for efficient and sustainable fishing, but also for furthering knowledge about the ocean environment. Through the echosounder buoys deployed at sea by the fishing industry, scientific researchers can have access to highly relevant, precise, and wide-spanning information on tuna's presence and abundance across the oceans. Indeed, for highly migratory species such as these, Tun-AI proves how these echosounder buoys can become the scientists' eyes at sea, giving further insight into tuna's migratory patterns, environmental preferences, and furthering knowledge on their behaviour and ecology, all in a cost-effective way. Undoubtedly, Tun-AI shows a new way of studying the ocean, highlighting the power of technology but also proving how cross-sectorial collaboration involving all stakeholders is essential to better understand and protect ocean resources.

Personal response

How did this cross-sector collaboration come about – did you initiate it?

For this project, collaboration was key, so involving all sectors was a given. On the one hand, the fishing industry has been essential in sharing data from their catches and from their echosounder buoys deployed at sea, while on the other hand Satlink helped us in interpreting the data and understanding how it was collected and transmitted. Of course, the sheer volume of data was immense, and that's where it made sense to involve experts in ML and AI, that were able to find the best way to process all the accumulated information required to gain insights into how to best use it.

Can you tell us more about how Tun-AI reduces bycatch? How is it able to distinguish biomass of tuna from other species around a buoy?

Using feedback from the fishing masters and captains that have been using echosounder buoys for years, we developed Tun-AI in a way that it would replicate their acquired knowledge. Tuna are known for their specific behaviour around floating objects, with very characteristic daily migrations to and away from the dFAD. Other species don't always show these same behaviours, so by using several days of information Tun-AI can find and identify those patterns that are typical of tuna. By also providing aggregation size estimates, fishermen can focus on the larger schools and substantially reduce the proportion of bycatch per set.

What further work are you planning on using Tun-AI for?

Our study on temporal dynamics of tuna around dFADs is only a first step in looking at the nature of aggregation and disaggregation. To continue exploring this topic, we would like to look at spatial patterns of tuna aggregations around dFADs, in particular with relation to the environment. Combining oceanographic data with Tun-AI's ability to process the echosounder buoy data, we hope to characterise the oceanographic drivers that might be at play when tuna associate to a floating object.

Could Tun-AI be adapted for use with other fish species?

That is a question we get asked a lot! Tun-AI is developed specifically for tuna given its tendency to aggregate around floating objects and form large schools. Furthermore, it is because it has a characteristic daily migration that Tun-AI can separate the signal of what is and what isn't tuna. For other species of fish, we would have to first characterise how they relate to floating objects, and how they are picked up by the echosounders, and then look into processing that data together with catch information to develop a similar suite of models.

What do you think is the most exciting advance Tun-AI has enabled?

Undoubtedly, the most exciting application of Tun-AI is its potential in terms of scientific research. Tuna are migratory species, and are very hard and expensive to track and study in their natural habitat. By collaborating with the fishing industry and using the same tools, we suddenly gain information on vast areas of the ocean at a fraction of the cost, which wouldn't be possible using traditional research methods.

Details

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Research Objectives

Technology provider Satlink teamed up with Komorebi AI Technologies to develop Tun-AI, using artificial intelligence to further scientific knowledge on tuna ecology and behaviour.

Bio

Alberto Torres Barrán has a PhD in computer science from Universidad Autónoma de Madrid and more than 10 years of experience in Machine Learning, both research and industry. He is currently the CTO at Komorebi AI.

David Gómez-Ullate Oteiza is professor of applied mathematics, Head of Faculty at the School of Science and Technology, IE University and Director of IE Research Datalab. He is also President of the Knowledge Transfer Committee of the Royal Spanish Mathematics Society and author of more than 60 research papers on applied mathematics and data science.

Kathryn Gavira-O'Neill is a marine biologist with over 7 years of experience, and currently the Head of Satlink's Science and Sustainability Department, which enables and coordinates collaborative projects with NGOs and scientific institutions all over the world to improve knowledge and conservation of the ocean's resources.

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- Spanish Ministry of Economy (Torres Quevedo programme)
- Autonomous Community of Madrid (Industrial PhDs programme)

Collaborators

- Satlink SL
- Komorebi AI Technologies SL
- University of Cádiz
- Universidad Carlos III

Further reading

- Navarro-García, M, Precioso, D, Gavira-O'Neill, K, et al, (2023) Aggregation dynamics of tropical tunas around drifting floating objects based on large-scale echo-sounder data. *Marine Ecology Progress Series*, 715 129–143.
- Precioso, D, Navarro-García, M, Gavira-O'Neill, K et al, (2022) TUN-AI: Tuna biomass estimation with Machine Learning models trained on oceanography and echosounder FAD data. *Fisheries Research*, 250, 106263.