A novel approach to quantifying drifting fish aggregating device use in the Pacific

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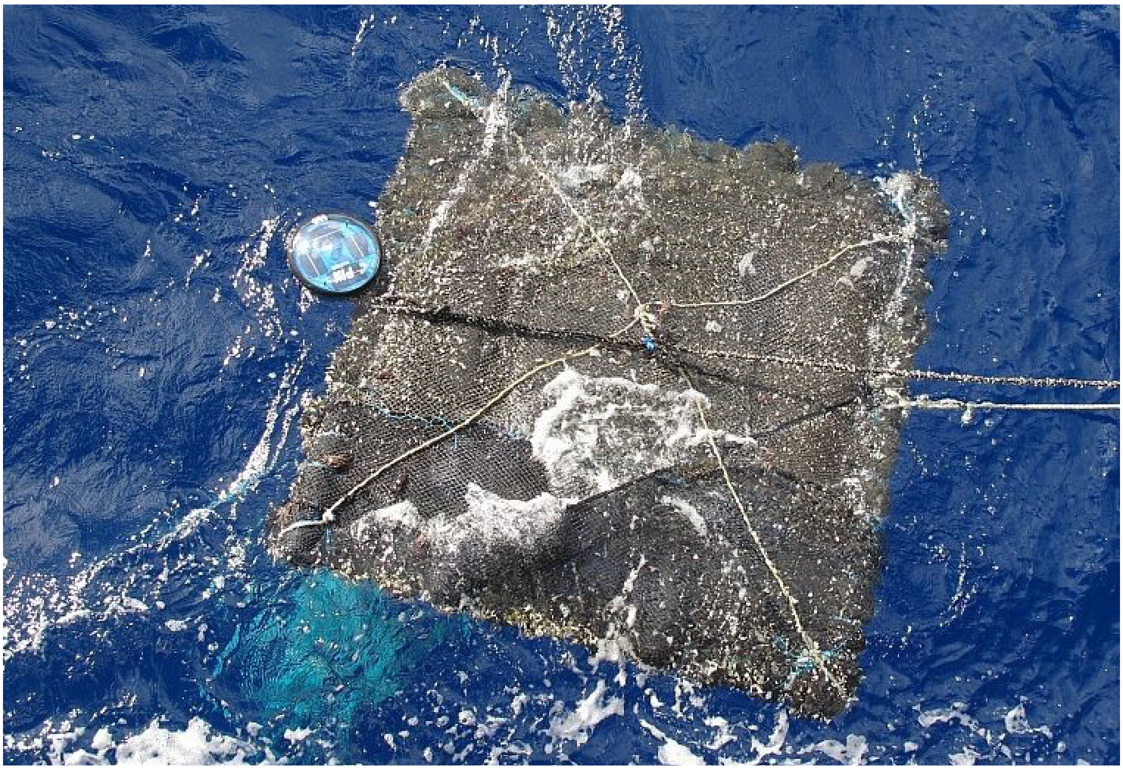

Figure 1. A drifting fish aggregating device equipped with a satellite echosounder buoy. (© SPC)

The western and central Pacific Ocean (WCPO) provides 52% of the world's five million tonnes of tropical tuna catch (Williams and Ruaia 2021). While stocks of the four main tuna species – skipjack, yellowfin, bigeye and albacore – are currently assessed as being fished sustainably, the industry is worth six billion dollars and is crucial for many Pacific Island nation economies, providing up to 84% of government revenue via fisheries access fees (Bell et al. 2021).

One of the main WCPO tuna fisheries is the purse-seine fishery, which relies on drifting fish aggregating devices (dFADs) for about 40% of the catch. Anchored FADs have long been used by artisanal and industrial fishers because many fish species such as tunas have a natural tendency to gather under and around floating objects. In the open ocean, purse-seine vessels have also used terrestrial debris and logs to locate tuna schools for many decades. Since the 1990s, however, bamboo rafts have been specifically designed and built by fishers to aggregate tuna schools, mostly skipjack tuna. Nowadays, modern dFADs are equipped with satellite buoys and sonar technology, which allow fishers to track dFADs and estimate the quantity of tuna beneath them (Fig. 1).

Knowing where, and how many, fish are present is clearly an advantage to the fishing industry. Fishing on dFADs has, therefore, allowed for a general increase in tropical tuna catches, while reducing the effort and costs spent in locating tuna schools. The development of dFAD fishing is thought to have become important for the efficiency of the purse-seine fleet targeting skipjack tuna. However, the use of dFADs can also have undesirable impacts, such as sustainability issues linked to catches of small bigeye and yellowfin tunas; increased bycatch, and environmental pollution; ghost fishing; and habitat damage from lost or abandoned dFADs. In addition, while the purse-seine fishery has 100% observer coverage, monitoring dFAD use remains challenging. Tracking the number of dFADs deployed annually, and their spatio-temporal prevalence, is important for assessing their influence on tuna fisheries, and environmental and ecological risks.

Over the last decade, the management of the purse-seine fishery by the Parties to the Nauru Agreement (PNA) and the Western and Central Pacific Fisheries Commission (WCPFC) has been through the implementation of two main mechanisms: an annual three to five month

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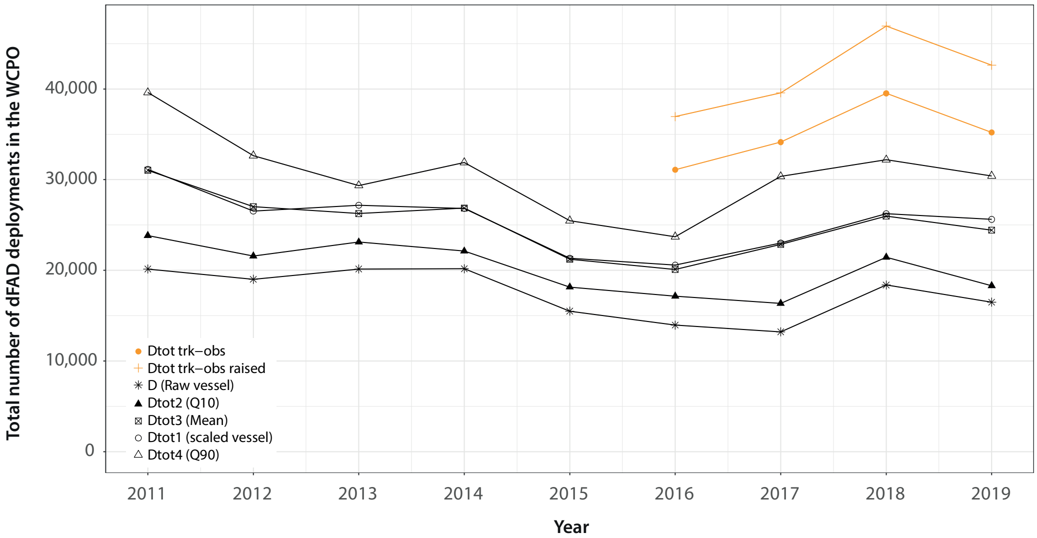

Figure 2. Estimates of the total number of dFAD deployments per year in the WCPO for all vessels. Different estimation metrics were used based on fishery data only (black line, with D representing the raw number of deployments recorded by observers; Dtot1 and Dtot3 representing the estimates per vessel and the average across vessels and Dtot2 and Dtot4 an 80th-percentile range of uncertainty around these values), and a combination of PNA dFAD tracking and observer data (orange line, with total and raised estimates). Figure from Escalle et al. (2021).

dFAD closure, during which all dFAD-related activities (e.g. fishing, deploying, servicing) are prohibited; and the implementation of the vessel day scheme by PNA, which sets a total allowable effort in fishing days per year across the main purse-seine fishing grounds in the WCPO. Both were implemented, in part, to manage the number of dFAD sets made by limiting total effort and reducing purse-seine dFAD fishing during some months of the year. This led to a stabilisation of the number of dFAD sets and associated catches. However, the number of dFADs deployed annually in the WCPO remains unknown. Recently, WCPFC adopted a conservation and management measure to limit the number of active buoys monitored by a vessel to 350. However, data and analyses to evaluate this management limit and its effectiveness are lacking. Estimating the ideal number of dFADs to strike a balance between profitability and limiting impacts on ecosystems and tuna stocks is, therefore, vital to ensuring sustainability of the resource and industry. But how can fisheries scientists keep track of how many dFADs are being used in order to achieve better analyses and provide advice for the management of their use?

A recent study from scientists of the Pacific Community (SPC), in collaboration with PNA, in the peer-reviewed journal *International Council for the Exploration of the Sea (ICES) Journal of Marine Science*, presented a novel approach to estimating the number of dFADs used in the WCPO.[2] This deeper understanding provides a firmer foundation for achieving profitable, yet sustainable, tuna fisheries that depend on dFAD use in the WCPO, as well as offering a model that could be used to inform estimation and monitoring of dFAD use in other ocean regions. This study, which sets the stage for the sustainable management of dFADs and for future scientific work, would not have been possible without a strong relationship and a considerable level of partnership between scientists, fisheries managers, and the fishing industry in the Pacific Islands region.

The study presents new ways of estimating the use of dFADs in the WCPO through a novel combination of four fisheries datasets over the period 2011–2019: at-sea observers' data, vessel logbook reports, vessel monitoring system data, and trajectories from the satellite buoys on dFADs. Using these data, which are often commercially sensitive and confidential, requires a secure collaboration between partners.

Combining these data sources for the first time, estimates of the number of deployments and active dFADs per vessel and in the whole WCPO were derived using two different approaches that combine fishery data with dFAD tracking data to evaluate trends in dFAD use across the entire WCPO between 2011 and 2019. SPC scientists found that between 20,000 and 40,000 dFADs are deployed per year, depending on the estimation methodology, with the total number of deployments appearing relatively stable over the last decade (Fig. 2). A striking result was the relatively stable trend in terms of dFAD deployment detected over the last decade, which is different from the increasing trends seen in other oceans that rely more heavily on dFADs. The annual number of total deployments estimated in the WCPO is nevertheless the highest of all oceans. Comparing our estimates of 20,000–30,000 for the WCPO in 2013 to estimates of 15,000 in the Indian Ocean; 18,000 in the Atlantic Ocean; and 19,000 in the eastern Pacific Ocean in 2013

[2] https://academic.oup.com/icesjms/advance-article/doi/10.1093/icesjms/fsab116/6307380

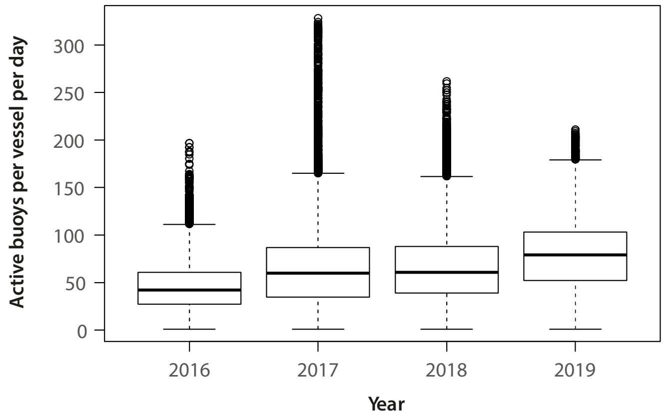

Figure 3. Annual variability in the raised number of active buoys per vessel and per day in the PNA dFAD tracking data for the top 50 vessels deploying the highest number of dFADs. Figure from Escalle et al. (2021).

(Fonteneau et al. 2015; Gershman et al. 2015; Maufroy et al. 2017). Although, the number of dFADs deployed is higher due to the scale of the fishery, less dependence on dFADs is found in the WCPO than in other oceans. Forty per cent of the WCPO purse-seine catch in 2019 was on floating objects, compared to approximatively 60%, 70% and 80% in the eastern Pacific Ocean, Atlantic Ocean and Indian Ocean, respectively.

An increasing trend was detected, this time from 2016 to 2019, in terms of the number of active buoys monitored per vessel (Fig. 3). This might indicate that vessels may share the position of their buoys with other vessels (e.g. vessels from the same company). The median number of active buoys monitored per vessel per day ranged from 45 to 75 during this period (Fig. 3), well below the current management limit of 350. The overall number of dFADs deployed has remained relatively stable, but vessels in the WCPO have access to more dFADs that are equipped with tracking and acoustic capabilities, thereby providing valuable information on positions and echosounder data.

The methods implemented represent a significant move towards improving the quality and quantity of data available for WCPO fishery managers through regional cooperation in collecting data, and scientific creativity in the way those data are analysed. Methods and results compiled will also provide a baseline to monitor and manage dFAD use in the WCPO, and a model that can be applied to other oceanic regions where dependence on dFADs is higher, yet data are lacking. It also demonstrates the confidence that Pacific fisheries can have in the way in which their data are managed and used by SPC and its partners. This in turn paves the way towards more sustainable and economically successful fisheries.

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