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CAUSES OF THE INCREASE IN FLOATING-OBJECT SETS IN THE EASTERN PACIFIC OCEAN IN RECENT YEARS: AN ANALYSIS (REVISED)

Jon López, Cleridy E. Lennert-Cody, Mark N. Maunder, Nickolas W. Vogel and Ernesto Altamirano

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SUMMARY

The increase in the number of floating-object sets was investigated using data on catch and effort for all trips by purse-seine vessels departing during 2010-2018. For the analyses, trips were grouped into five categories, by IATTC vessel size class, whether the vessel had a Dolphin Mortality Limit (DML) and, for Class-6 vessels with a DML, the level of dolphin-set activity during the trip. Results indicate that the increase in floating-objects sets in the purse-seine fishery since 2015 is due mainly to Class 1-5 vessels, and trips by Class-6 vessels with a DML that were not focused on fishing for tunas associated with dolphins. For Class 1-5 vessels, the increase appears to be due to a switch from unassociated sets to floating-object sets, not to an increase in number of trips or vessels making floating-object sets. For trips by Class-6 vessels with a DML that were not focused on fishing on tunas associated with dolphins, the increase appears to be due to increased effort, whether measured by number of trips, vessels, days fishing, or number of sets per day fishing or per vessel.

1. BACKGROUND

Purse-seine sets on floating objects in the eastern Pacific Ocean (EPO) have increased substantially since the mid-1990s, especially in recent years (FSR 4, FSR 16), despite restrictions on adding capacity to the fleet since 2002 (Resolution C-02-03). Since the late 1990s, most floating-object sets by IATTC Class-6 vessels are estimated to have been made on fish-aggregating devices (FADs) (FSR 4, FSR 16); the percentage of floating-object sets by smaller purse-seine vessels that were made on FADs is not known. Due to the size and species of the tunas caught, the use of non-degradable materials in FAD construction, and higher bycatch rates of many species than in other purse-seine set types, FAD fishing is widely considered to have negative impacts on the ecosystem and tuna populations (Dagorn *et al*. 2012).

To address the potential impact of FAD fishing on tuna populations, Resolution C-17-02 limited the number of active FADs a vessel can have at any given moment. However, this measure may not be enough to guarantee that the status of the stocks is healthy. Because of that, in 2018 staff proposed a combined limit on unassociated and floating-object sets, to keep fishing mortality from increasing (SAC-09-15), but this proposal was not adopted by the Commission. Developing alternative conservation measures is a long-term process, and meanwhile, the number of sets on floating-objects keeps increasing.

This document investigates the causes of this continued increase, through an analysis of fleet components.

2. DATA AND METHODS

For this study, vessels were divided into two categories: IATTC capacity class 6 (carrying capacity > 363 tons), and capacity classes 1-5 (carrying capacity ≤ 363 t). Under the Agreement on the International Dolphin Conservation Program (AIDCP), only Class-6 vessels are allowed to fish for tunas associated with dolphins. Class-6 vessels that intend to make sets on dolphin-associated tuna (DEL sets) must apply for a Dolphin Mortality Limit (DML); other vessels (*i.e*. Class-6 vessels without a DML, and all Class 1-5 vessels) are limited to setting on floating-object-associated tuna (OBJ sets) and on unassociated schools of tuna (NOA sets). It is noted that any Class-6 vessel may apply for a DML, regardless of its intended fishing mode; DMLs are voluntary, and have no additional economic cost for the vessel owner, except those associated with gear requirements.

Catch and effort data collected by observers or, if observer data were not available, abstracted from vessel logbooks, were used in this analysis[1]. Data were limited to purse-seine trips departing during 2010-2018. Data for 2018 trips that did not carry an observer, and for the 2019 portion of 2018-2019 carryover trips[2], are preliminary. For the starting year of the analysis, 2010 was selected because it is assumed that since then echo-sounder buoys have been in regular use in the FAD fishery in the EPO, and technology has been more homogeneous than in earlier years (Lopez *et al*. 2014).

Trips were grouped into five categories, by vessel size class, the DML status of the vessel at the start of the trip and, for Class-6 DML vessels, the level of DEL activity during the trip (Figure 1), as follows:

- **Category 1**: trips by Class 1-5 vessels;
- **Category 2**: trips by Class-6 non-DML vessels;
- **Category 3**: trips by Class-6 DML vessels with ≤ 1 DEL sets (minor DEL fishing);
- **Category 4**: trips by Class-6 DML vessels with >1 DEL sets, but with DEL sets < 50% of the trip sets (moderate DEL fishing);
- **Category 5**: trips by Class-6 DML vessels with ≥ 50% DEL sets (major DEL fishing).

The analysis was conducted at the trip level because a Class-6 vessel's DML status can change within a year, as well as from year to year. Most vessels are allocated an annual DML, but lose it if they do not make at least one DEL set before 1 April; some second-semester DMLs are issued, and are similarly forfeit if no DEL sets are made by 1 October. A portion of the DMLs forfeited during the year can be reallocated to other vessels, based on their performance and other criteria, including compliance with AIDCP regulations. Vessels that exceed their DML may not make any more DEL sets during the remainder of the year, and may be ineligible for a DML the following year.

To investigate changes in the purse-seine fishery over time, the following indicators (summaries) were

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[1] All Class-6 vessels are required to carry on-board observers on all trips, and detailed observer data are thus available for all trips of these vessels. For trips by smaller vessels, which rarely carry observers, data are abstracted from vessel logbooks.

[2] Trips that began in 2018 but finished in 2019

computed, by trip departure year (2010-2018) and trip category (1-5)[3]:

a. number of sets, by set type (NOA, OBJ);
b. total number of sets (all set types: DEL+NOA+OBJ);
c. number of trips;
d. number of vessels;
e. number of days fishing;
f. average trip duration (days);
g. number of OBJ/NOA/ALL sets per day fishing;
h. number of OBJ/NOA sets per vessel;
i. catch of tropical tunas (yellowfin+bigeye+skipjack) per OBJ set.

3. RESULTS

The changes in the various indicators during the entire 2010-2018 period and in recent years (2015-2018), by trip category, are described below.

3.1. Category 1: Trips by Class 1-5 vessels

The number of sets of all types for Category-1 trips has increased slightly since 2010, but the trends by set type are quite different (Figure 2). The number of OBJ sets has increased steadily since 2010, to about double the 2010-2011 levels, whereas the number of NOA sets has fluctuated, but has decreased continuously since 2015. These changes have resulted in long- and short-term increases in the proportion of OBJ sets (Figure 3), which indicates that the increase in OBJ sets in recent years is leading to a decrease in the number of NOA sets.

The increase in the number of OBJ sets (Figure 2) was accompanied by a slight increase in the number of days fishing over the 9-year period, while the number of vessels and average trip duration have remained nearly constant (Figure 4). The number of trips increased through 2013 and has fluctuated since then, decreasing slightly overall; however, despite that decrease, it is still above 2010 levels (Figure 4).

The slight increasing trend in days fishing (Figure 4) is not proportional to the increasing trend in number of OBJ sets (Figure 2), resulting in an increasing trend in the number of OBJ sets per day fishing and per vessel (Figures 5 and 6). However, it leads to decreasing trends in the number of NOA sets per day fishing and per vessel, particularly since 2015. The overall result is a decrease in the trend of all sets per day fishing, particularly since 2015. The catch per set of tropical tunas in OBJ sets (Figure 7) decreased slightly prior to 2015, but has been fairly stable since then. The catch rate for Category 1 trips is, however, the lowest catch rate of all the trip categories.

3.2. Category 2: Trips by Class-6 non-DML vessels

As with Category 1, the number of OBJ sets for Category 2 trips has increased steadily since about 2010, resulting in an increase in the number of all purse-seine sets, despite little long-term trend in the number of NOA sets (Figure 2). However, since 2015, the number of OBJ sets has remained relatively stable, whereas the numbers of NOA sets and of all sets have decreased. These changes in numbers of sets by set type have led to a slightly increasing proportion of OBJ sets over the nine-year period (Figure 3).

This long-term trend in the number of sets by set type (Figure 2) was accompanied by a long-term increase in the number of trips, vessels and days fishing, while the average trip duration has been fairly stable (~40-50 days) (Figure 4). Since 2015, however, the first three have decreased slightly, while the last has

[3] Because the data used in this analysis are from the IATTC georeferenced Catch and Effort database, the total number of sets across trip categories may be slightly different than that shown in the Fishery Status Report.

increased slightly.

In the long term, there has been an overall increase in the number of OBJ sets per day fishing, whereas the number of NOA sets per day fishing has fluctuated, but overall remained fairly stable (Figure 5). These dynamics have led to a general increase in the number of all sets per day fishing. The slight increase in number of vessels for this category (Figure 4), combined with the long-term increase in numbers of OBJ sets (Figure 2), has resulted in an overall long-term increase in OBJ sets per vessel (Figure 6). The catch of tropical tunas per OBJ set has been variable over the 9-year period, but shows both a slight long-term and a more pronounced short-term decrease (Figure 7).

3.3. Categories 3-5: Trips by Class-6 DML vessels

The DML trip categories with minor and moderate DEL fishing (Categories 3 and 4) have shown long-term increases in the number of OBJ sets, accelerating in 2016-2018, depending on the category (Figure 2). The number of OBJ sets in Category 5 (major DEL fishing) increased in 2018 (Figure 2). The increase in OBJ sets since 2016 for Categories 3 and 4 coincides with increases in number of trips and days fishing (Figure 4). The proportional increases in OBJ sets were greatest for Category 3 and least for Category 5 (Figure 3).

The increases since 2016 in the number of trips, vessels, and days fishing for Category-3 trips appear to mirror decreases since 2016 in the same indicators for Category-5 trips. Average trip duration since 2015 has increased for all three trip categories, the amount depending on the category (Figure 4).

The recent increases in numbers of OBJ sets for Categories 3-5 (Figure 2) have led to increases in the number of OBJ sets per day fishing (Figure 5) and per vessel (Figure 6) for Categories 3 and 4 and, to a lesser degree, for Category 5. The catch per OBJ set has decreased over the nine-year period for all three trip categories (Figure 7).

4. Discussion

The analyses presented in this document indicate that the increase in OBJ sets in the purse-seine fishery since 2015 is mainly due to Class 1-5 vessels (Category 1), and trips of Class-6 DML vessels that were not primarily fishing on tunas associated with dolphins (Categories 3 and 4, Figures 2 and 3). In the case of Category 1, the increase appears to be due to a switch from NOA sets to OBJ sets (Figures 2 and 3), not to an increase in number of trips or vessels (Figure 4). In the case of Categories 3-4, the increase in OBJ sets appears to be due to an increase in effort (trips, vessels, days fishing, number of sets per day fishing and per vessel; Figures 4, 5 and 7). Preliminary analyses of individual vessel behavior suggest diverse origins for this "new" effort, including Class 1-5 vessels being converted into Class-6 vessels, vessels that were traditionally non-DML vessels or DML vessels that traditionally conducted major dolphin fishing.

The increases in effort in Category 3-4 trips suggest plasticity in the fishing behavior of the vessels in those categories. For example, the increase in Category-3 OBJ sets since 2017 (Figure 2) corresponds to a decrease in the percentage of Category-3 trips that carried a helicopter aboard (Figure 8). Because helicopters are considered important for making DEL sets (*e.g.*, Figure 8, Categories 4 and 5), the decrease in the proportion of trips with a helicopter in Category 3 may indicate that previously non-DML vessels are acquiring DMLs as a form of insurance, to give them the option of fishing on tunas associated with dolphins. (As noted above, applying for a DML is voluntary, open to all Class-6 vessels, and has no additional economic cost for the vessel owner, except those associated with gear requirements.) Another example is the continued high proportion of Category 4 trips that carried a helicopter (Figure 8), despite an increase in OBJ sets since 2016 for that category (Figure 2). Since 2016 vessels in Category 4 deployed

FADs, although at lower levels than vessels in Category 2[4] (Table 1). FAD-fishing has several advantages (less search time, less sets with no catch) over some other fishing modes that may require additional skills (Scott and Lopez 2014), and those advantages could be exploited in a scenario of declining abundance ofyellowfin tuna, which is predominantly caught in DEL sets (SAC-10-08).

In summary, apparently some vessels may be keeping their options open; the current management regime in the EPO allows them to do so, and effectively fish with few restrictions. Beyond closures that apply to all vessels[5], DML vessels operate under the rules of the AIDCP, but those are intended to protect dolphins, not conserve tunas. The only additional limitation on the FAD fishery are the limits on the number of active FADs that a vessel may have (Resolution C-17-02), but those limits may be too high.

TABLE 1. Percentage of Class-6 FAD deployments, by trip category, and number of deployments per vessel, by trip category, for trips departing during 2016-2018. The percent deployment was computed as the number of FAD deployments in each trip category divided by the total number of deployments in all four trip categories. The number of deployments per vessel was computed as the number of deployments per trip category divided by the number of vessels in the trip category. Data source: IATTC observer data base.

Trip category	% of deployments			Deployments per vessel		
	2016	2017	2018	2016	2017	2018
2	92.8	88.5	84.8	161	203	246
3	4.2	8.0	11.2	28	51	79
4	2.4	2.5	3.0	8	12	16
5	0.6	1.0	1.0	1	3	3

There are some clear patterns that explain the increase in floating-object sets when viewed in terms of trip categories, but there is a lot of variability among individual vessels, complicating the prediction of future fleet behavior and the development of effective management strategies. Preliminary results from vessel-specific time-series analyses by the staff identified vessels that moved between Category 2 and Categories 3-4, from Category 5 to Categories 3-4, and from Category 1 to Category 2 and then Categories 3-4. The causes of these vessel-level transitions, which occurred across CPCs, are unclear and difficult to determine. Therefore, any management strategy considered should be either robust to these vessel-level transitions, adapt to them, or restrict them.

Not all patterns presented in this document are fully understood. In particular, the causes of the decrease in catch per set of tropical tunas (Figure 7) are not known. In addition to possible decreases in the abundance of some tuna species, the long-term decreasing trend may also be due to changes in fleet behavior, such as shorter periods between deploying FADs and setting on them. However, this cannot be estimated with data currently available to IATTC staff; it will require the high-quality FAD tracking information thatthe new observer form, the new FAD form, and the staff recommendation for provision of detailed buoy data (SAC-10-19, Section 5.3) are intended to provide.

References

Dagorn, L., Holland, K. N., Restrepo, V., Moreno, G. 2012. Is it good or bad to fish with FADs? What are the real impacts of the use of drifting FADs on pelagic marine ecosystems? Fish and Fisheries: n/a-n/a.

Lopez, J., Moreno, G., Sancristobal, I., Murua, J. 2014. Evolution and current state of the technology of echo-sounder buoys used by Spanish tropical tuna purse seiners in the Atlantic, Indian and Pacific

[4] Assumes that these deployments represent an intention to fish on FADs, since acting as a tender vessel (deploying FADs for other vessels to set on) has been prohibited in the EPO since 1998 (Resolution C-98-05).

[5] The 72-day and *corralito* closures (Resolution C-18-01).

Oceans. Fisheries Research. 155: 127 – 137.

Scott, G. P. and Lopez, J. 2014. The use of FADs in tuna fisheries. European Parliament. Policy Department B: Structural and Cohesion Policies: Fisheries IP/B/PECH/IC/2013-123: 70p.

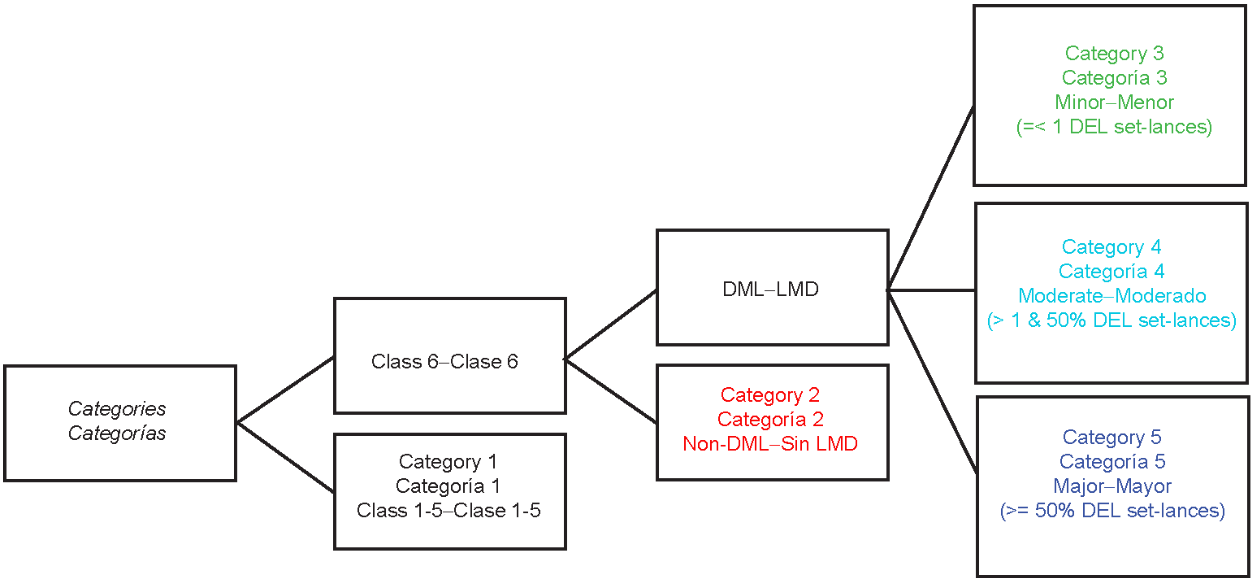

FIGURE 1. Trip categories used in this study.
FIGURA 1. Categorías de viajes usadas en este estudio.

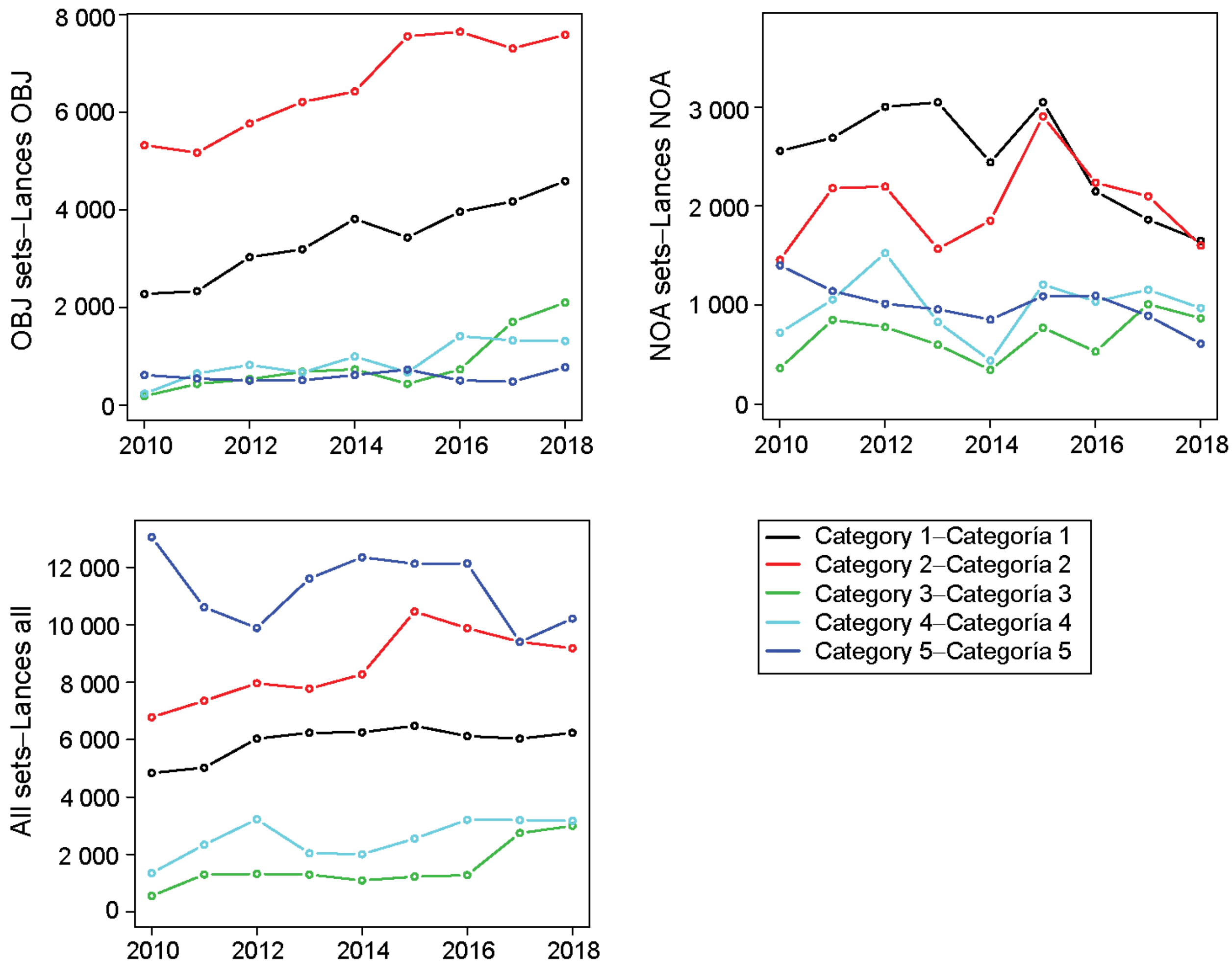

FIGURE 2. Annual number of sets, by set type (floating-object (OBJ), unassociated (NOA)), and all sets, by trip category and departure year, 2010-2018. See text for description of trip categories.
FIGURA 2. Número anual de lances, por tipo de lance (objeto flotante (OBJ), no asociado (NOA)), y todos lances, por categoría del viaje y año de zarpe, 2010-2018. Ver descripción de las categorías de viajes en el texto.

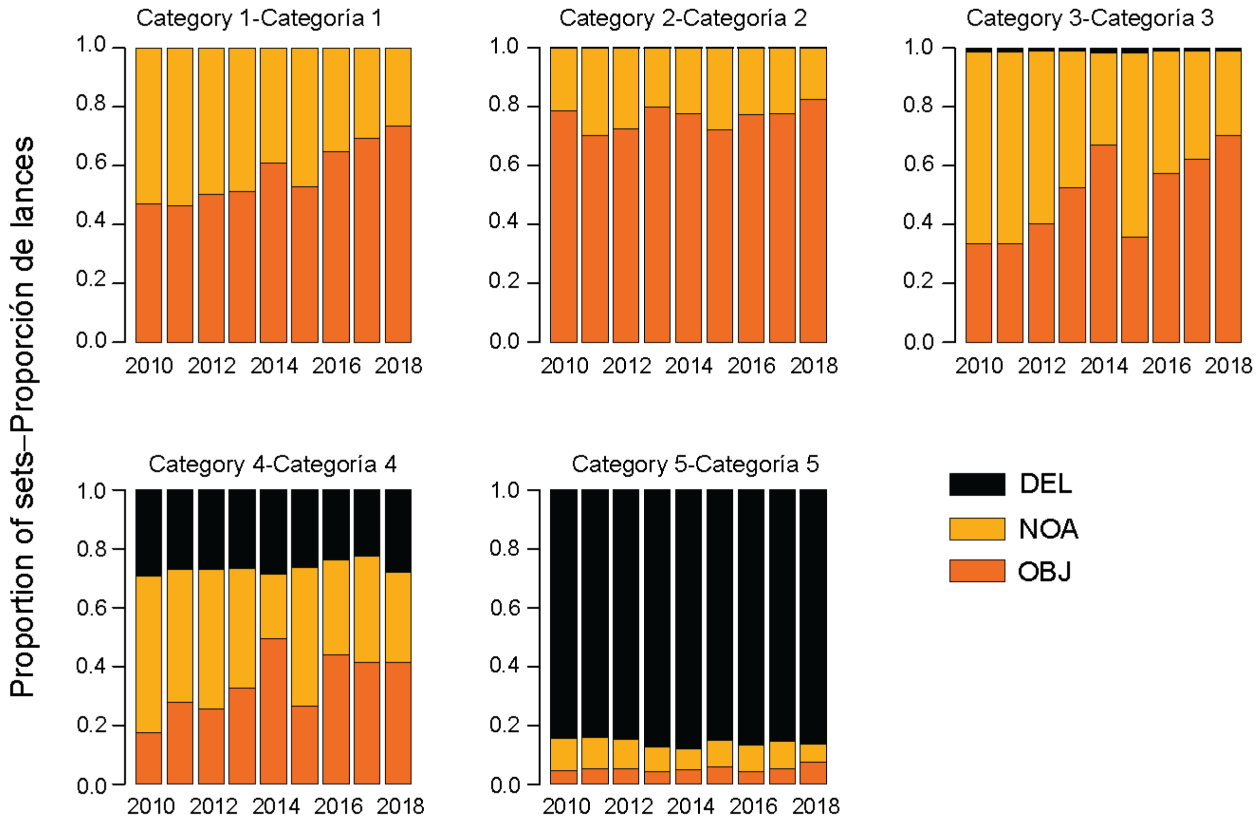

FIGURE 3. Proportion of sets, by set type, by trip category and departure year, 2010-2018. See text for description of trip categories.

FIGURA 3. Proporción de lances, por tipo de lance, por categoría del viaje y año de zarpe, 2010-2018. Ver descripción de las categorías de viajes en el texto.

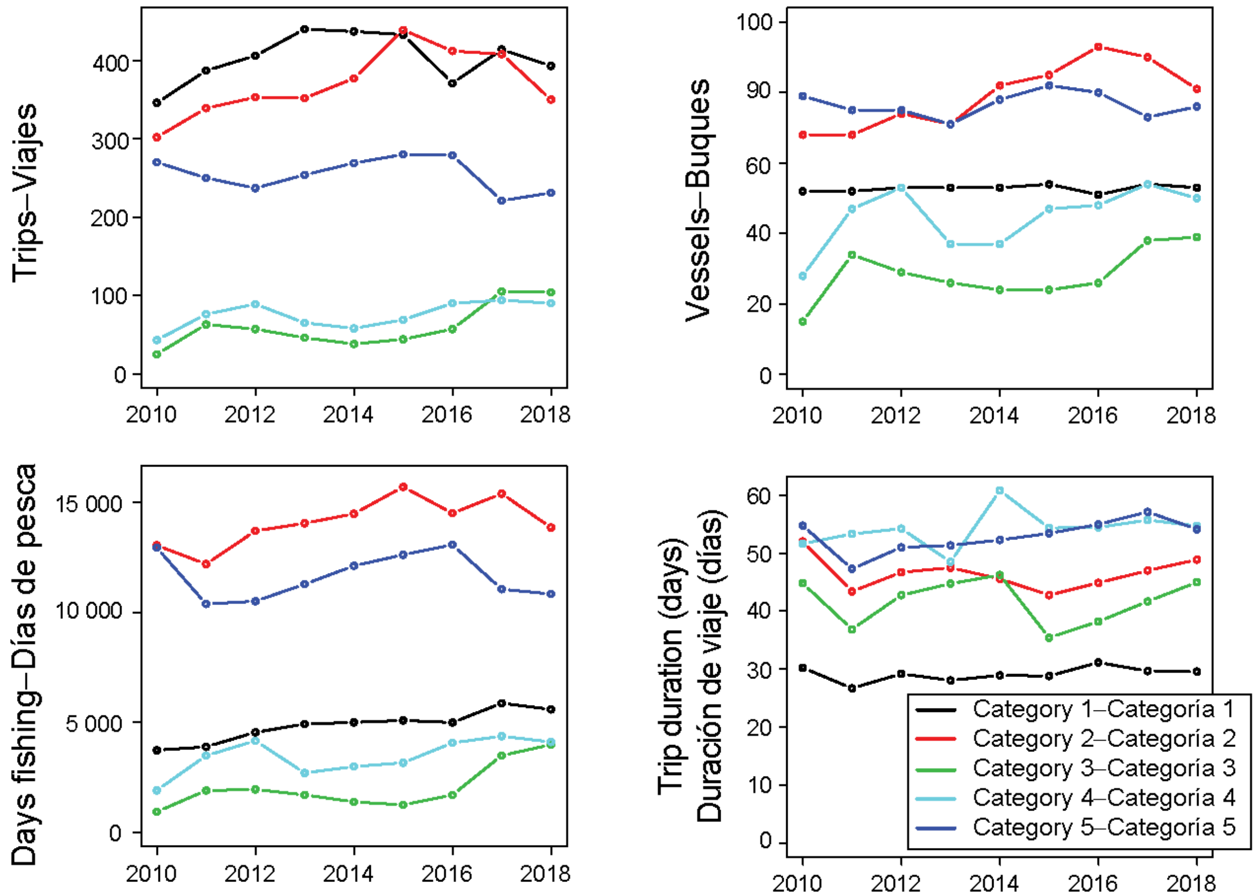

FIGURE 4. Number of trips, vessels, and days fishing, and average trip duration, by trip category and departure year, 2010 - 2018. The number of vessels is computed as the number of unique vessel codes in each trip category for trips departing in a particular year. As such, specific vessels may be in more than one trip category in a year if they made trips in that year that were classified into different categories. See text for description of trip categories.

FIGURA 4. Número de viajes, buques, días de pesca, y duración promedio de viaje, por categoría de viaje y año de zarpe, 2010-2018. Se calcula el número de buques como el número de códigos únicos de buque en cada categoría de viaje para viajes que zarparon en un año particular. Como tal, buques específicos podrían estar en más de una categoría en un año si realizaron viajes en ese año que fueron clasificados en diferentes categorías. Ver descripción de las categorías de viajes en el texto.

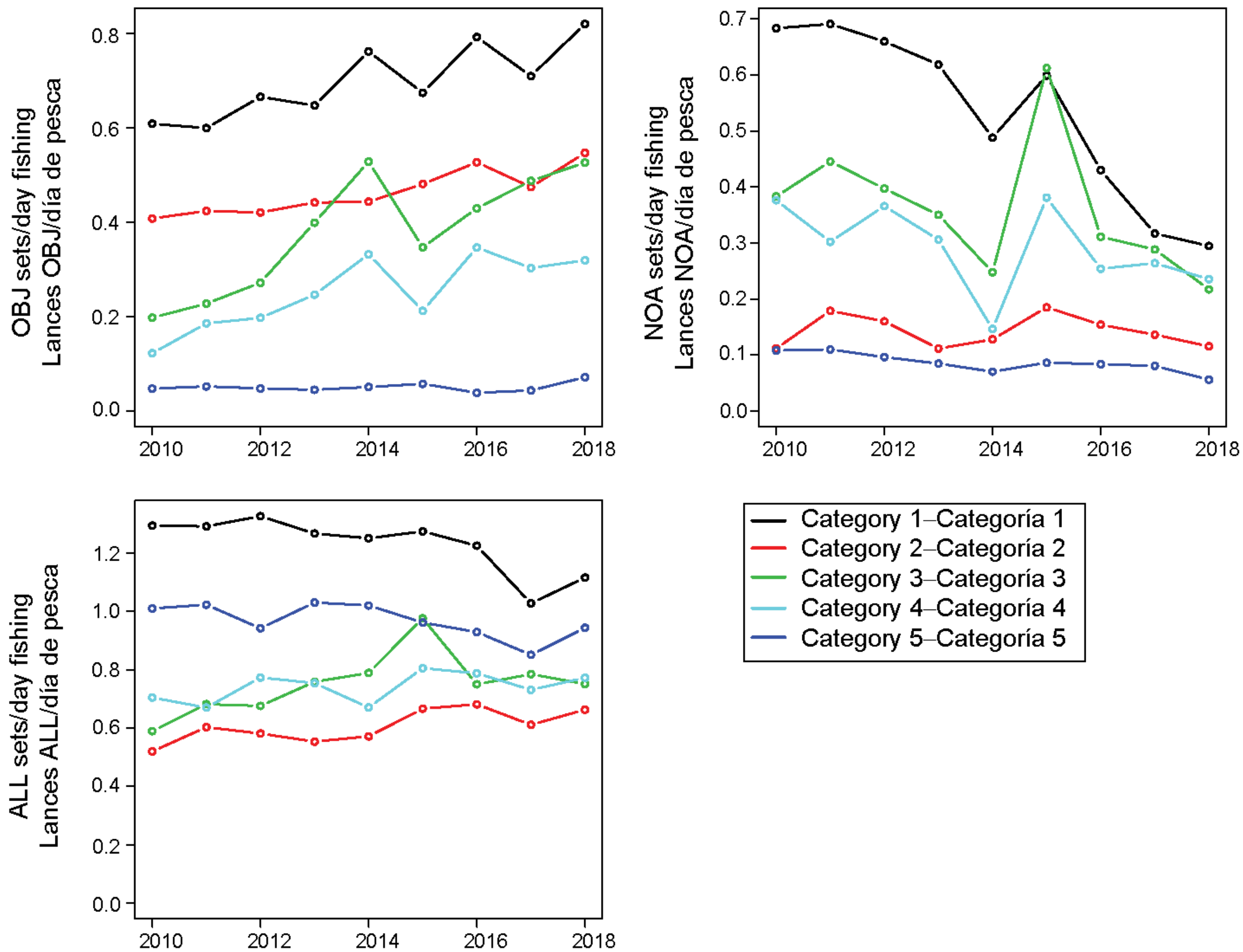

FIGURE 5. Number of sets per day fishing by set type (floating-object, OBJ; unassociated, NOA), by trip category and departure year, 2010 - 2018. See text for description of trip categories.

FIGURA 5. Número de lances por día de pesca por tipo de lance (objeto flotante, OBJ; no asociado, NOA), por categoría de viaje y año de zarpe, 2010-2018. Ver descripción de las categorías de viajes en el texto.

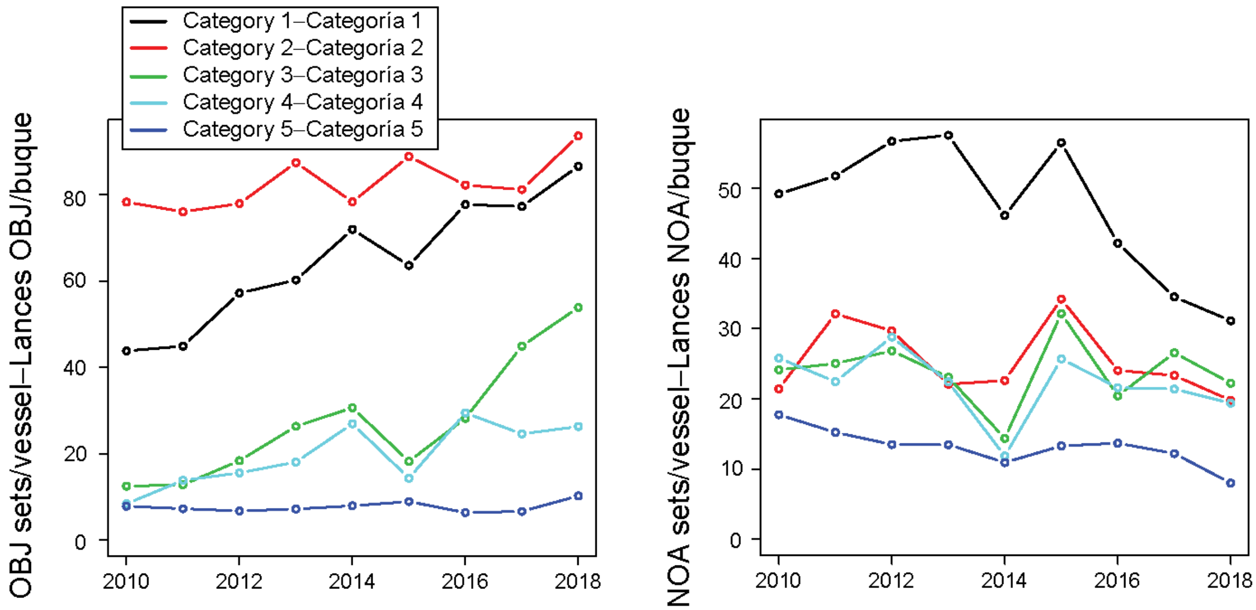

FIGURE 6. Number of sets per vessel, by set type (floating-object, OBJ; unassociated, NOA), 2010-2018, by trip category and depature year, 2010 - 2018. See text for description of trip categories.
FIGURA 6. Número de lances por buque, por tipo de lance (objeto flotante, OBJ; no asociado, NOA), por categoría de viaje y año de zarpe, 2010-2018. Ver descripción de las categorías de viajes en el texto.

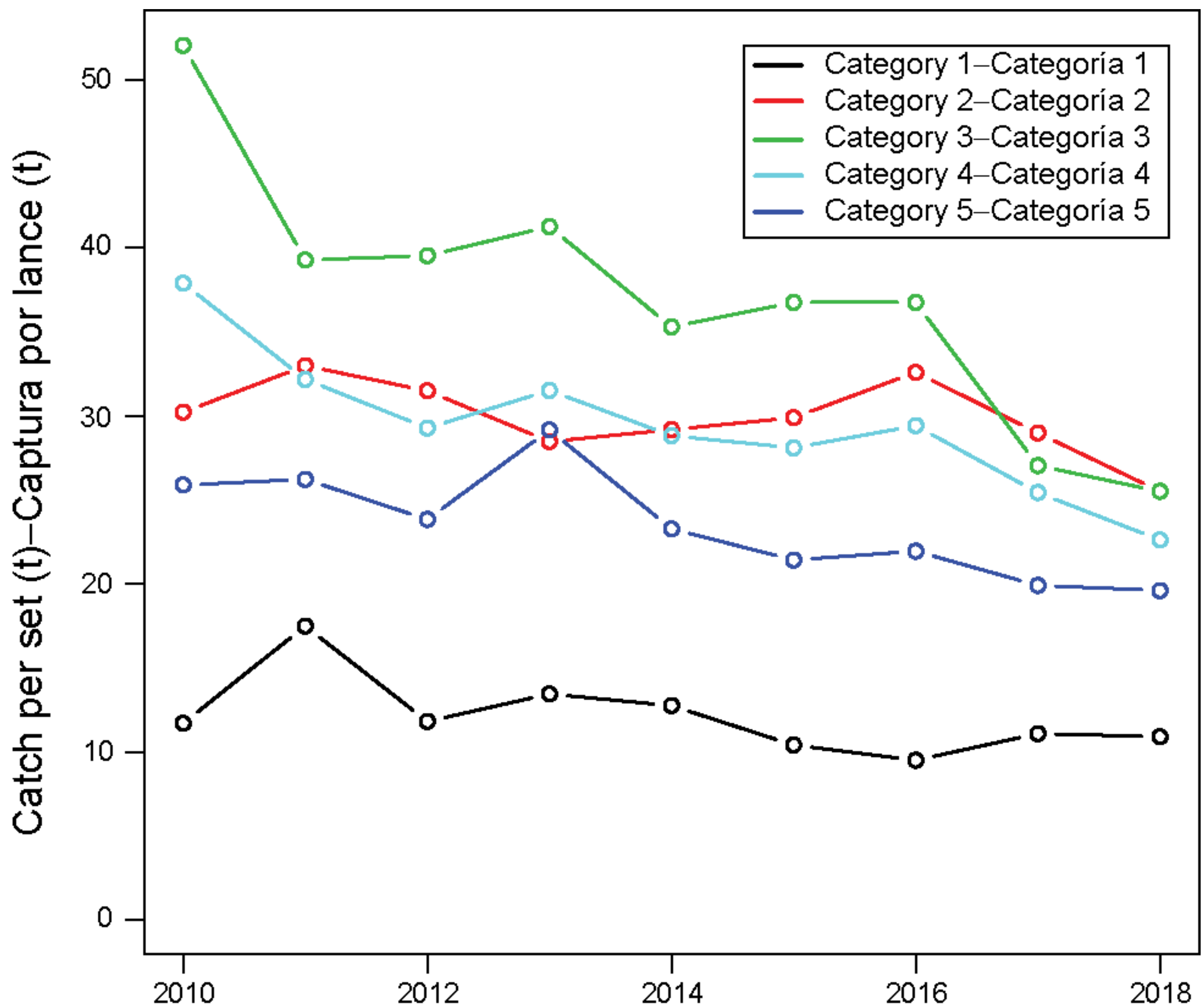

FIGURE 7. Catch, in tons (t) of tropical tunas (yellowfin+bigeye+skipjack) per OBJ set, by trip category and departure year, 2010-2018. See text for description of trip categories.
FIGURA 7. Captura, en toneladas (t), de atunes tropicales (aleta amarilla+patudo+barrilete) por lance OBJ, por categoría de viaje y año de zarpe, 2010-2018. Ver descripción de las categorías de viajes en el texto.

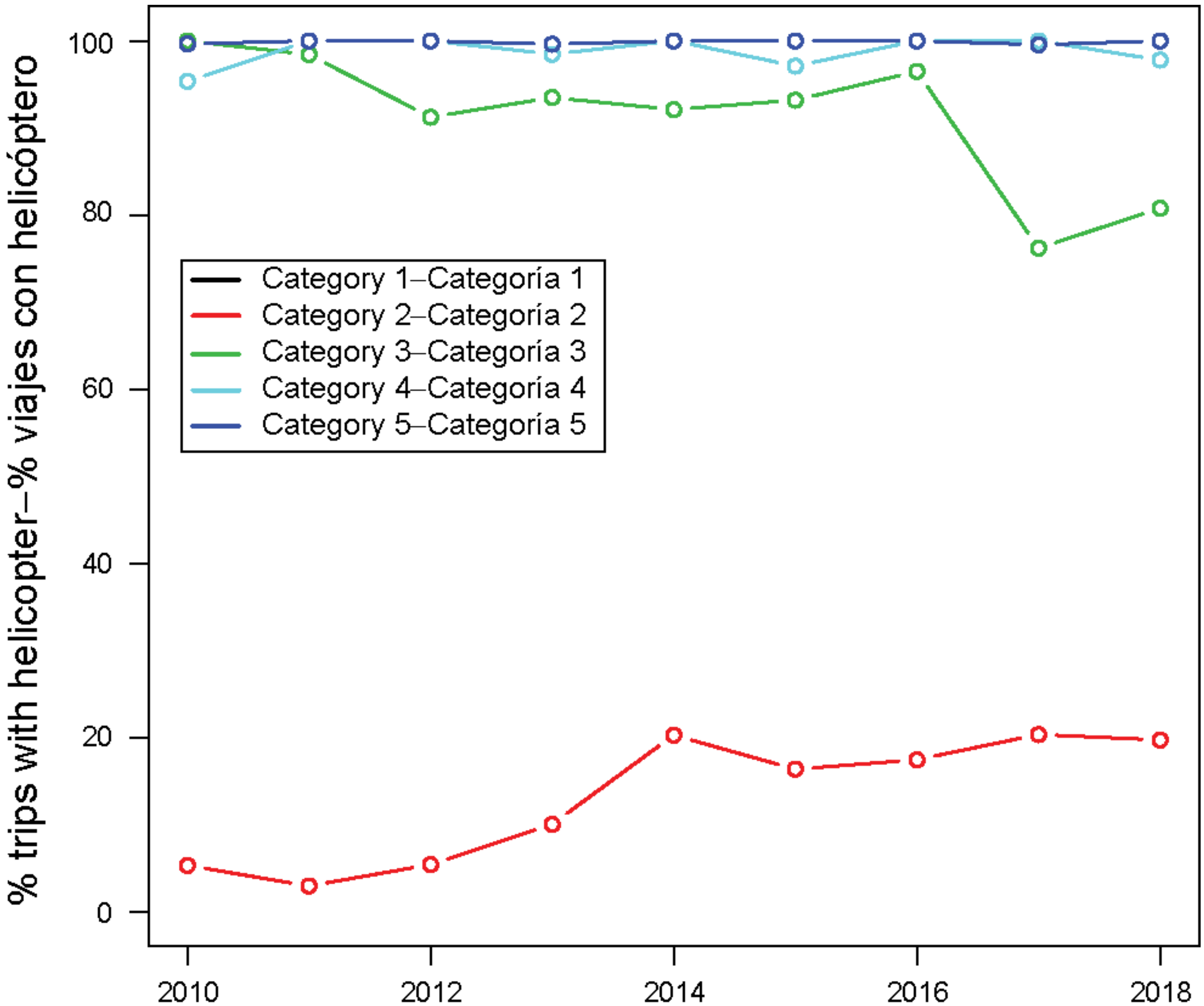

FIGURE 8. Percentage of trips by Class-6 vessels with a helicopter aboard, by trip category and departure year, 2010 - 2018. Data on the presence /absence of a helicopter aboard the vessel for each trip were obtained from the observer database. For a given departure year, the percentage of trips with a helicopter aboard in each cateogory was computed as 100 x the number of trips in the category with a helicopter aboard divided by the totla number of trips in the category. See text for description of trip categories.

FIGURA 8. Porcentaje de viajes por buques de clase 6 con helicóptero a bordo, por categoría de viaje y año de zarpe, 2010-2018. Se obtuvieron los datos de presencia/ausencia de helicóptero a bordo del buque para cada viaje de la base de datos de observadores. Para un año de zarpe dado, el porcentaje de viajes con helicóptero a bordo en cada categoría es calculado como 100 x el número de viajes en la categoría con helicóptero a bordo dividido por el número total de viajes en la categoría. Ver descripción de las categorías de viajes en el texto.