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EVALUATION OF THE RELATIONSHIP BETWEEN ACTIVE PURSE-SEINE FISHING CAPACITY AND FISHING MORTALITY IN THE EASTERN PACIFIC OCEAN

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INTRODUCTION

The Inter-American Tropical Tuna Commission (IATTC) limits the total capacity of the purse-seine fleet as a management measure to control effort. The capacity limits allow the use of temporal closures (and a small spatial closure) to control fishing effort in an attempt to keep fishing mortality at or below levels that correspond to the maximum sustainable yield (MSY). The capacity limits do not specify what type of purse-seine set (on floating objects, on yellowfin tuna associated with dolphins, and on unassociated schools) the vessels can make, although vessels that set on yellowfin associated with dolphins are required to have a dolphin mortality limit (DML). In this analysis, we correlate estimates of fishing mortality from the yellowfin and bigeye tuna stock assessments with the capacity limits to evaluate how effective the capacity limits are at controlling effort.

METHODS

The annual exploitation rate (U_y) on bigeye (BET) and yellowfin (YFT) tunas is calculated as catch/biomass (C/B), where B is defined as the vulnerable biomass from the stock assessment model, calculated using the average selectivity of the appropriate fisheries during 1993-2012, weighted by their respective catches. Catches of all purse-seine fisheries during 1993-2012 are included in the calculation of the exploitation rate; 1993 was chosen as the starting year because the equatorial offshore fishery on floating objects began around that year. The analysis for bigeye is based on the selectivity of the purse-seine fisheries on floating objects, and for yellowfin the selectivity of purse-seine fisheries associated with dolphins and on unassociated schools.

$$U_y = \frac{C_y}{B_y}$$

$$B_y = \frac{\sum_{q,a} N_{y,q,a} s_a}{4}$$

$$\acute{s}_a = \frac{\sum_g s_{g,a} \sum_{y,q} C_{g,y,q}}{\sum_{g,y,q} C_{g,y,q}}$$

$$s_a = \frac{\acute{s}_a}{\max(\acute{s})}$$

$$C_y = \sum_{g',q} C_{g,y,q}$$

where *g* indexes the gears used to calculate the selectivity, which differs between bigeye and yellowfin, and *g'* indexes the gears used to calculate catch (all surface gears), *y* is year, *a* is age, *q* is quarter, *N* is numbers of fish, and *s* is selectivity.

The exploitation rate of all three species (yellowfin, bigeye, and skipjack) was calculated as the weighted average based on the average catch during 1993-2012. Skipjack are primarily caught on floating objects, so the bigeye and skipjack purse-seine catch on floating objects were combined in the weighting. The two exploitation rates (one for yellowfin and one for bigeye) were normalized by dividing each one by its respective average rate during 1993-2012 before taking the weighted average, so the resulting exploitation rate is only a relative measure, The purpose of applying a weighting is to roughly reflect the allocation of fleet capacity amongst the floating-object catches versus the catches in dolphin and unassociated school sets.

The effective capacity (E'_y) is calculated by adjusting the active capacity by the amount of time the fishery is not closed:

$$E'_y = E_y * O_y$$

where *E* is the active purse-seine capacity in the EPO and *O* is the proportion of the year that the fishery is open. The exploitation rate associated with MSY was converted into capacity by using the regression of effective capacity on relative combined exploitation rate.

RESULTS

The yellowfin tuna exploitation rate generally follows the total effective capacity from 1975 to 1993, but the relationship breaks down after 1993 (Figure 1). The exploitation rate for bigeye tuna was low until 1993, so it does not correlate with the total effective capacity (Figure 2); after 1993 there is a vague relationship between exploitation rate and total effective capacity. The exploitation rate for bigeye has been increasing and is currently above the MSY level, but the capacity is currently below the MSY level. The effective capacity has been relatively stable since 1999.

The fishing capacity of vessels with Dolphin Mortality Limits (DMLs) has changed over time. In particular, there was more capacity with DMLs during 1998-2000 and 2004-2008 (Figure 3). For yellowfin, the correlation between exploitation rate and effective capacity was not improved when capacity was restricted to vessels with DMLs (Figure 4), whereas for bigeye it was improved when capacity was restricted to vessels without DMLs (Figure 4).

The combined relative exploitation rate of all three species (Figure 6) did not correlate as well as the exploitation rate for bigeye only, but the regression is statistically significant ($P<0.01$). The current combined exploitation rate is above the MSY level, but the current capacity is at the MSY level. The combined relative exploitation rate at MSY is about 1.10. Substitution of the MSY exploitation rate into the regression equation in Figure 6 produces an estimate of effective capacity of 176,707 cubic meters (m^3) at the level of MSY.

DISCUSSION

When the purse-seine fishery mainly targeted yellowfin tuna, the exploitation rate for that species generally followed the effective capacity. However, when the floating-object fishery expanded in the mid-1990s the correlation was degraded. Restricting the capacity to vessels with DMLs only did not improve the correlation, due probably to the large amount of yellowfin caught in sets on unassociated schools, which are not limited to vessels with DMLs. The correlation between bigeye tuna exploitation rate and effective capacity was improved when capacity was restricted to vessels without DMLs. Further separating capacity into vessels that fish mainly for tuna associated with floating objects may improve the correlations.

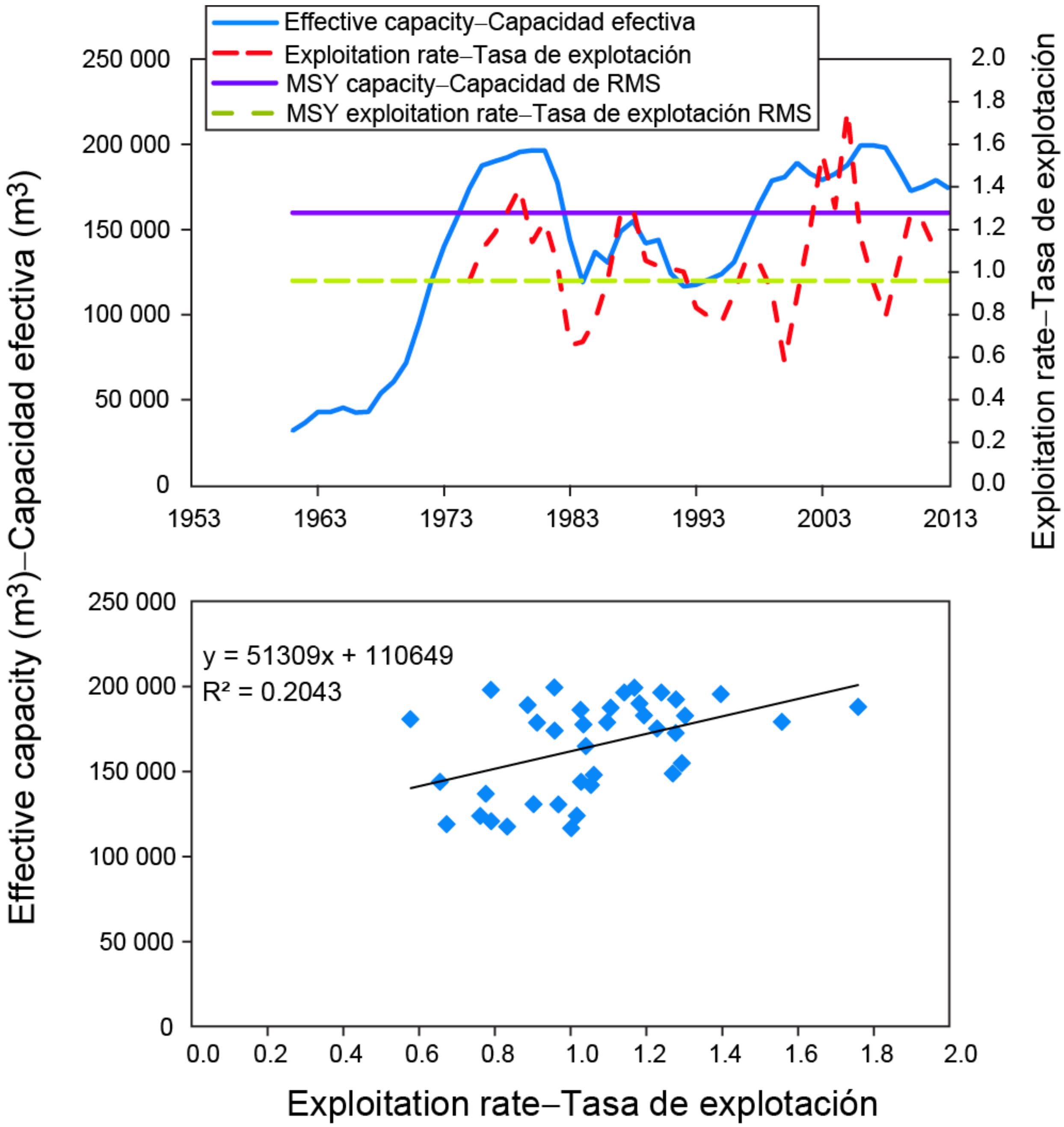

FIGURE 1. Comparison of exploitation rate with effective capacity for yellowfin tuna. The lower panel is restricted to the years 1975 to 2012

FIGURA 1. Comparación de la tasa de explotación y la capacidad efectiva para el atún aleta amarilla. El panel inferior está limitado a los años 1975-2012.

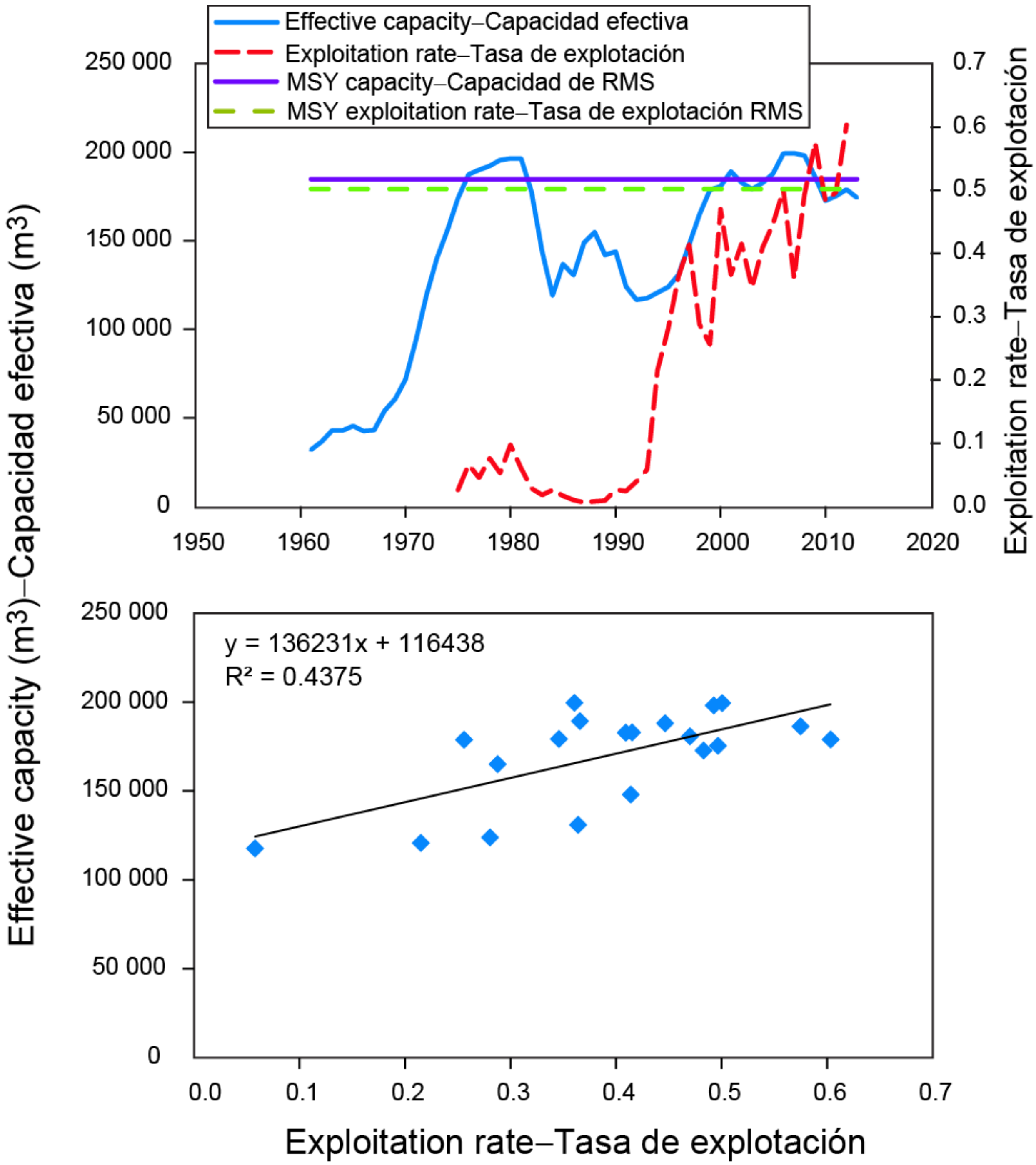

FIGURE 2. Comparison of exploitation rate with effective capacity for bigeye tuna. The lower panel is restricted to the years 1993 to 2012

FIGURA 2. Comparación de la tasa de explotación y la capacidad efectiva para el atún patudo. El panel inferior está limitado a los años 1993-2012.

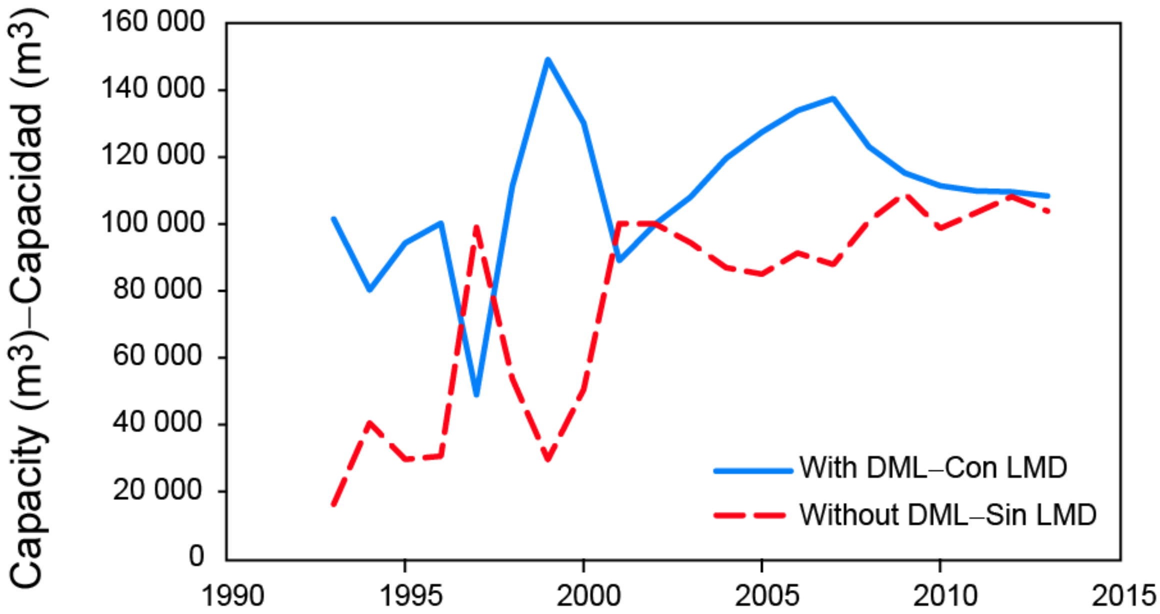

FIGURE 3. Total capacity of purse-seine vessels with and without dolphin mortality limits (DMLs), 1993-2012.
FIGURA 3. Capacidad total de los buques cerqueros con y sin límite de mortalidad de delfines (LMD), 1993-2012.

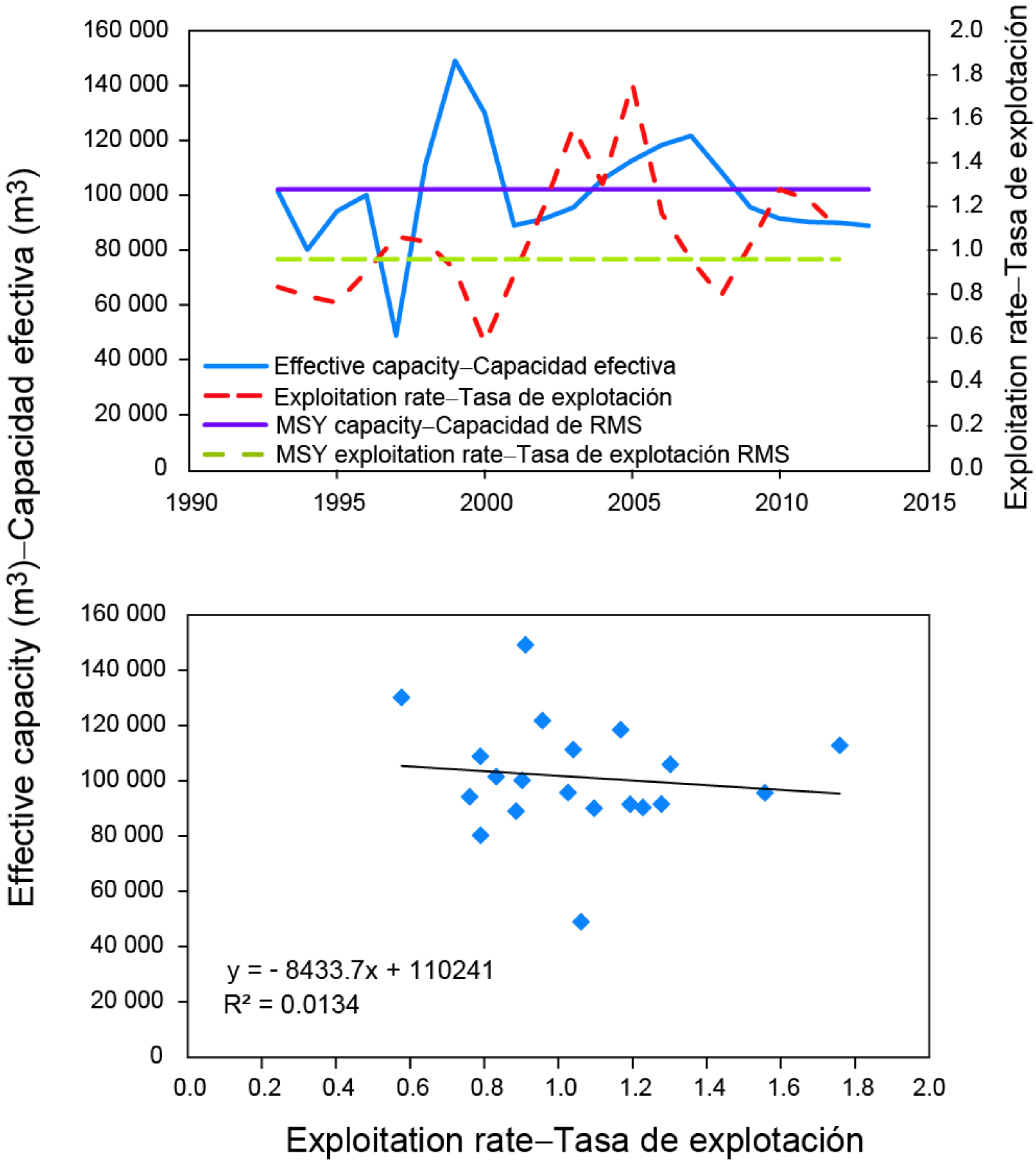

FIGURE 4. Comparison of exploitation rate with effective capacity of purse-seine vessels with dolphin mortality limits (DMLs) for yellowfin tuna, 1993-2012

FIGURA 4. Comparación de la tasa de explotación y la capacidad efectiva de los buques con límite de mortalidad de delfines (LMD) para el atún aleta amarilla, 1993-2012.

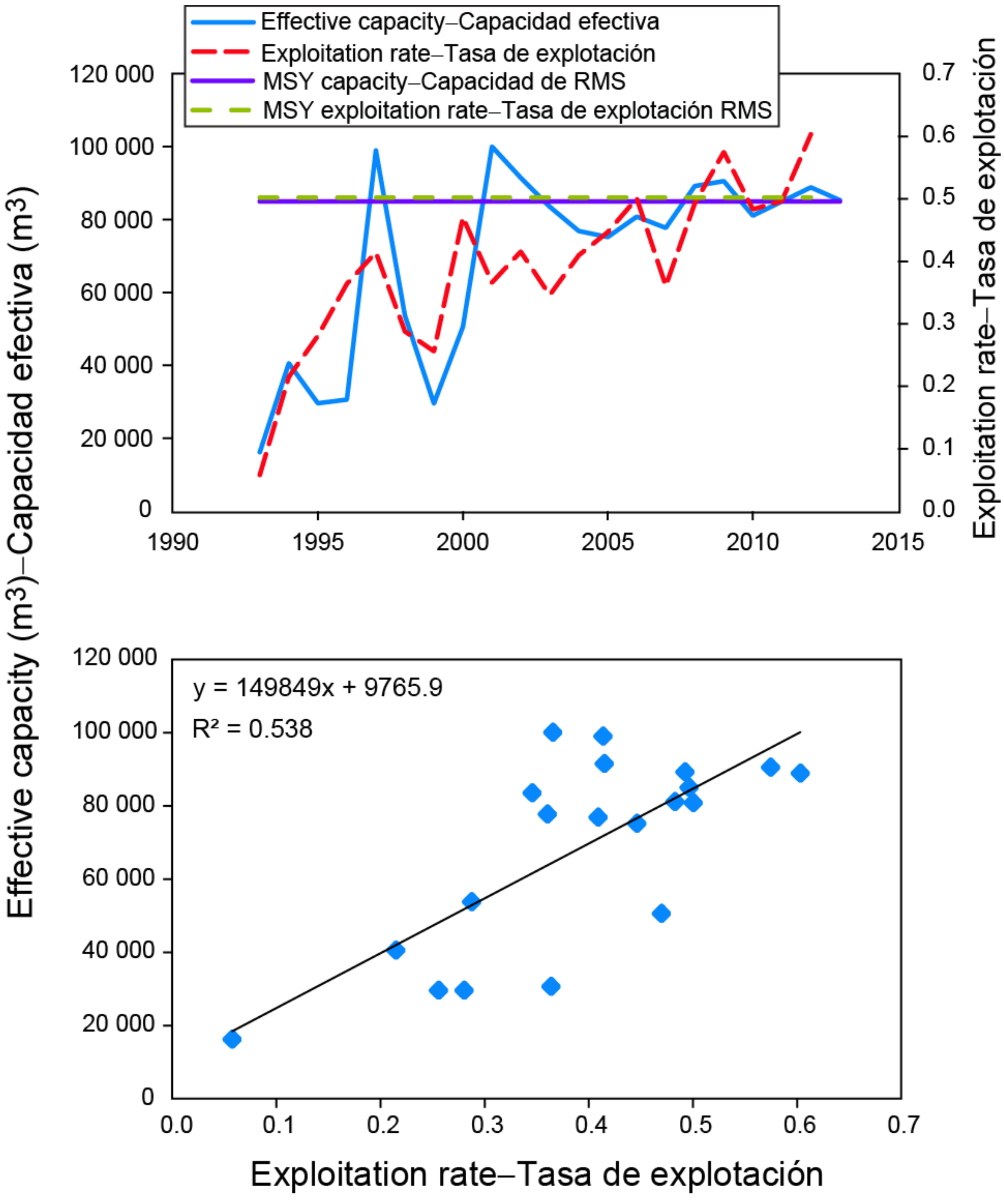

FIGURE 5. Comparison of exploitation rate with effective capacity of purse-seine vessels without dolphin mortality limits (DMLs) for bigeye tuna, 1993-2012.
FIGURA 5. Comparación de la tasa de explotación y la capacidad efectiva de los buques sin límite de mortalidad de delfines (LMD) para el atún patudo, 1993-2012.

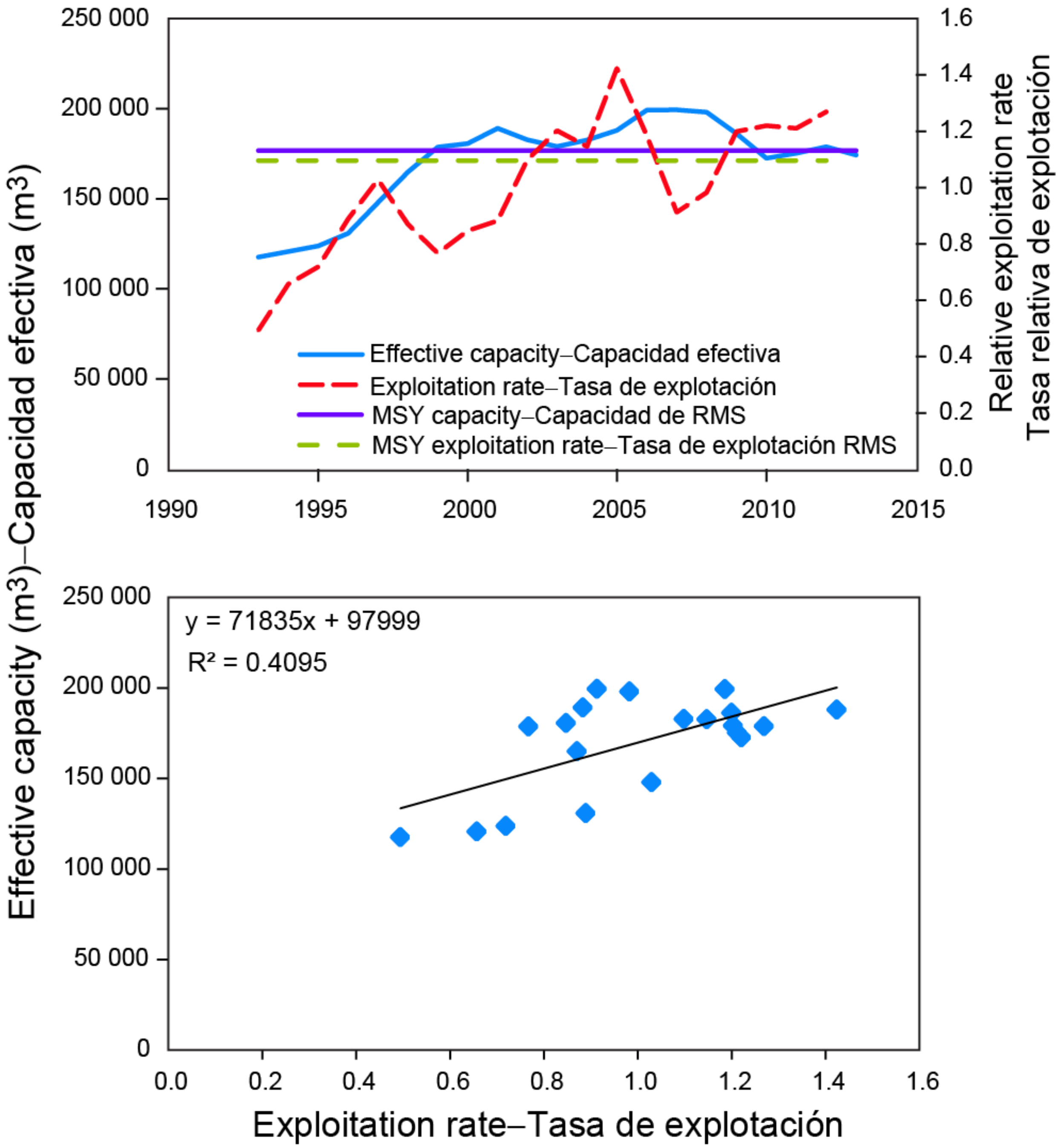

FIGURE 6. Comparison of a weighted average of relative exploitation rate for yellowfin and bigeye with effective capacity, 1993-2012

FIGURA 6. Comparación de un promedio ponderado de la tasa de explotación de aleta amarilla, patudo y capacidad efectiva, 1993-2012.