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UPDATED STOCK STATUS INDICATORS FOR SILKY SHARKS IN THE EASTERN PACIFIC OCEAN (1994-2014)

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The results of two recent genetics studies support assessing and managing the populations of silky sharks (*Carcharhinus falciformis*) in the western and eastern Pacific Ocean separately. One of the studies suggests a further division of silky sharks in the eastern Pacific Ocean (EPO) into two stocks, approximately along the Equator.

An attempt by the IATTC staff to assess the status of the silky shark in the EPO using conventional stock assessment models has been severely handicapped by major uncertainties in the fishery data, mainly regarding catch levels in the early years, which may be why the model is unable to explain the population declines observed in the early period of the assessment (1994-1998) (Document SAC-05 INF-F). Although this stock assessment attempt has produced a substantial amount of new information about the silky shark in the EPO (*e.g.*, absolute and relative magnitude of the catch by different fisheries and their selectivities), the absolute scale of population trends and the derived management quantities are compromised. Therefore, an alternative scientific basis for management advice is urgently needed. Since a conventional stock assessment was not possible, the staff proposed a suite of possible stock status (or stability) indicators (SSIs) which could be considered for managing the northern and southern stocks of silky sharks in the EPO (SAC-05-11a). The present paper updates the indices based on standardized catch-per-unit-effort (CPUE) in purse-seine sets on floating objects (CPUE-OBJ) with data for 2014.

Spatial distribution maps provide a simple quantitative overview of changes through time in both species occurrence and abundance. For silky sharks, they are available for average bycatch-per-set (BPS) from purse-seine sets on floating objects in the EPO, for small (< 90 cm), medium (90-150 cm), and large (> 150 cm) size classes separately (Figures 1a-c), and all silky sharks (Figure 1d). For all size classes north of the equator, there is an apparent reduction in bycatch rates (transition from predominantly red- and yellow-colored 1° areas to predominantly green- and blue-colored 1° areas). This reduction seems particularly strong in the most recent period (2011-2013), and apparently begins much earlier (around the mid-2000s) for large sharks. Silky shark catch rates were noticeably higher (red and yellow-colored 1° areas; Figure 1) in 2014. However, this may be the result of increased availability, rather than abundance, of silky sharks due to a transition to a period dominated by positive (warmer than average) SST anomalies, which were felt in 2014 and have become stronger towards 2015.

For the northern stock, the CPUE-OBJ indicator shows an initial sharp decline over a wide spatial range (1994-1998), followed by a period of stability (1996-2006), and possibly increase (2006-2010). However, there are indications that any such increase has been reversed in recent years (2010-2013) (Figure 2).

Observers record catches of silky sharks by size class: small (< 90 cm), medium (90-150 cm), and large (>150 cm) (Figure 3a). The relative trends described above for all sharks (Figure 2) generally apply to the individual size categories. However, there is more inter-annual variability in the trends observed for small sharks, which is not surprising since the small shark class can be seen as a proxy indicator for recruitment (ages 0 and 1). The sharp decline seen for medium and large sharks during 1994-1998 is not as marked for small sharks, which suggests that recruitment has not been greatly affected over time. For better comparison of relative trends across size classes, Figure 3b presents the mean-scaled standardized CPUE.

For the southern stock, there is a major decline in bycatch rates (transition from predominantly red- and yellow-colored 1° areas to predominantly green- and blue-colored 1° areas) (Figures 1a-d). This decline is particularly marked for medium and large sharks around the early- to mid-2000s (Figures 1b-c). Small individuals are relatively scarce in the southern area. It is uncertain where the recruitment to the southern stock originates. The CPUE-OBJ indicator for the southern stock shows a sharp decline during 1994-2004, followed by a period of stability at much lower levels (Figure 2). The trends for medium and large sharks are similar (Figure 3a, b).

The CPUE-OBJ trends are corroborated by a different type of standardized indicator (presence/absence) produced from other set types (dolphin and unassociated) (Figure 4).

An analysis of trends by sub-area in the northern EPO suggests that the recent increases in silky shark trends (Figures 2 and 3) may be the result of a combination of spatiailly-distinct factors. Indicators updated with data for 2014, by sub-area, in the north (Figure 5) show little to no recent increase for small and medium-sized sharks in the nearshore region (Area 4). Recent increases are apparent for small and medium sharks in the other areas; however, they are only apparent for large sharks in the offshore (Area 2) and far northern (Area 1) areas. Thus, the overall recent increasing trends in the northern area (Figures 2 and 3) may in fact reflect an integration of spatially-distinct processes, including the effect of fishing pressure closer to the coast, and the arrival of adults from the west, perhaps as a result of recent environmental changes.

No stock status target and limit reference points have been developed for silky sharks based on these indicators. In addition, no harvest control rules have been developed and tested. At this point, the indicators cannot be used directly for determining the status of the stock or for establishing catch limits: they should be used in combination with other information for those purposes. In terms of management, it is critical that precautionary measures be implemented immediately to allow silky sharks populations to rebuild in the EPO.

With respect to future research on SSIs for silk sharks, priority should be given to management strategy evaluation (MSE) work to simulation test and identify the reference points and harvest control rules that will achieve the conservation goals for silky sharks in the EPO.

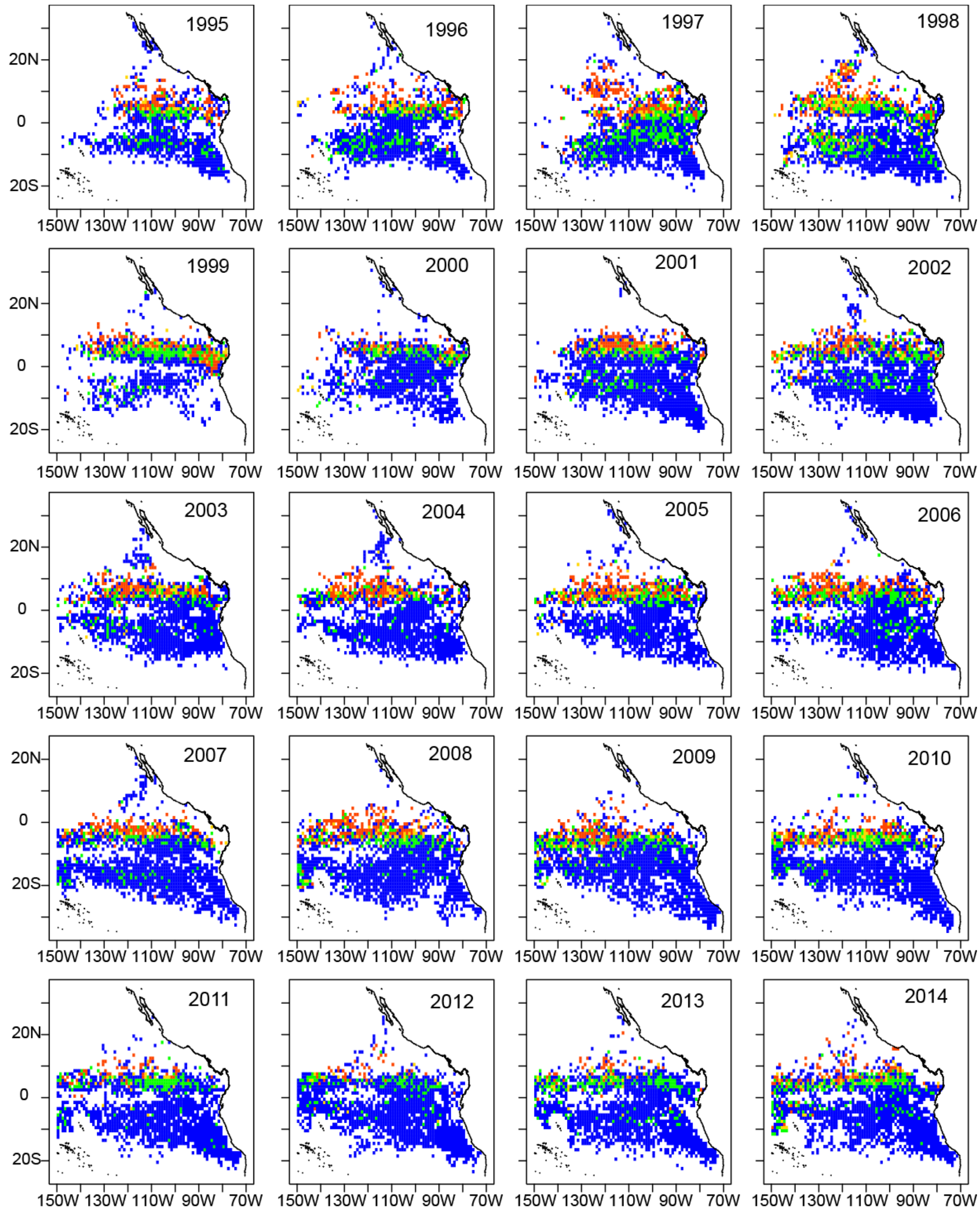

FIGURE 1a. Average bycatch per set in floating-object sets, in numbers, of small (< 90 cm total length) silky sharks, 1995-2014. Blue: 0 sharks per set, green: ≤ 1 shark per set; yellow: 1-2 sharks per set; red: > 2 sharks per set.

FIGURA 1a. Captura incidental media por lance en lances sobre objetos flotantes, en número, de tiburones sedosos pequeños (< 90 cm de talla total), 1995-2014. Azul: 0 tiburones por lance, verde: ≤ 1 tiburones por lance; amarillo: 1-2 tiburones por lance; rojo: > 2 tiburones por lance.

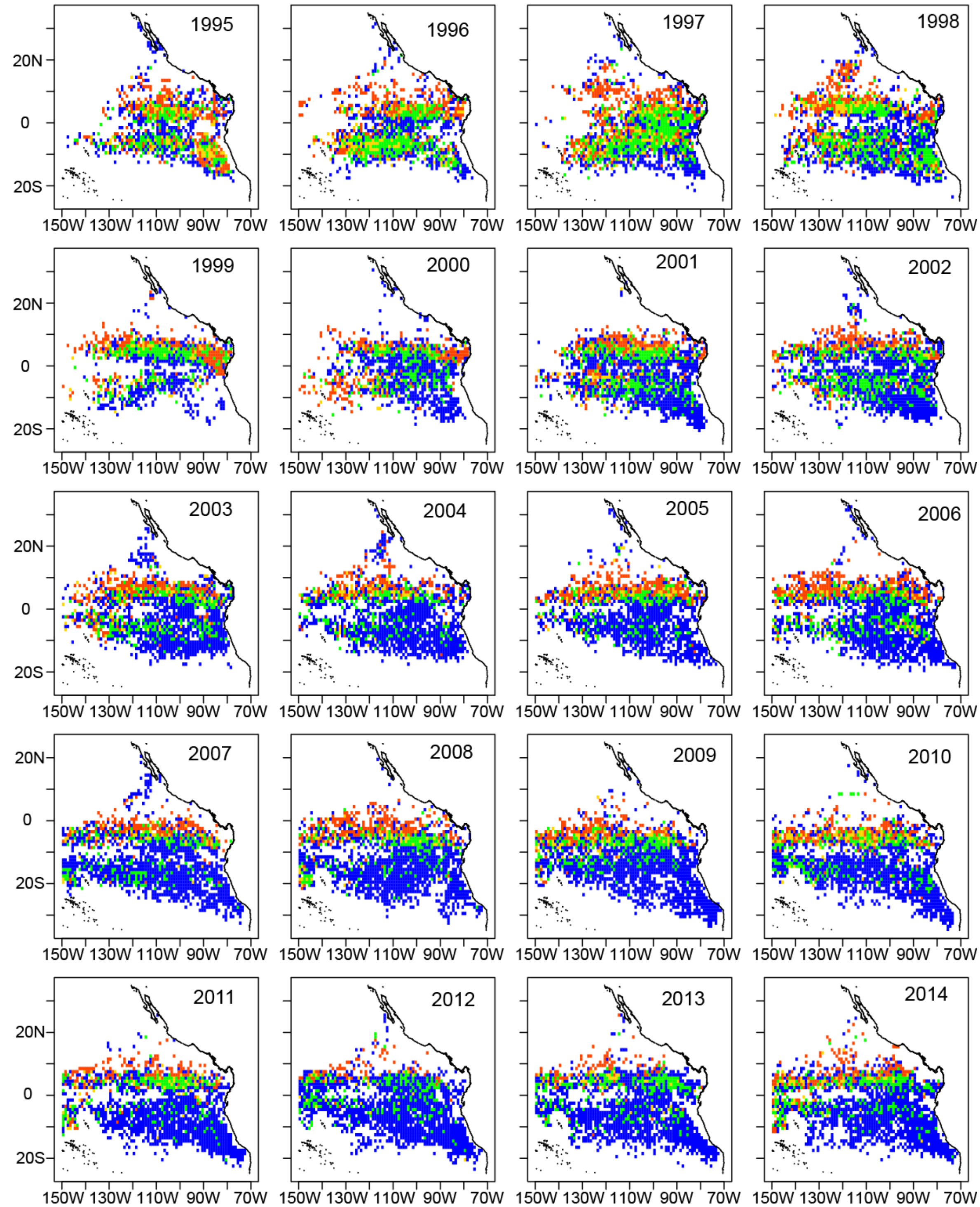

FIGURE 1b. Average bycatch per set in floating-object sets, in numbers, of medium (90-150 cm total length) silky sharks, 1995-2014. Blue: 0 sharks per set, green: ≤ 1 shark per set; yellow: 1-2 sharks per set; red: > 2 sharks per set.

FIGURA 1b. Captura incidental media por lance en lances sobre objetos flotantes, en número, de tiburones sedosos medianos (90-150 cm de talla total), 1995-2014. Azul: 0 tiburones por lance, verde: ≤ 1 tiburones por lance; amarillo: 1-2 tiburones por lance; rojo: > 2 tiburones por lance.

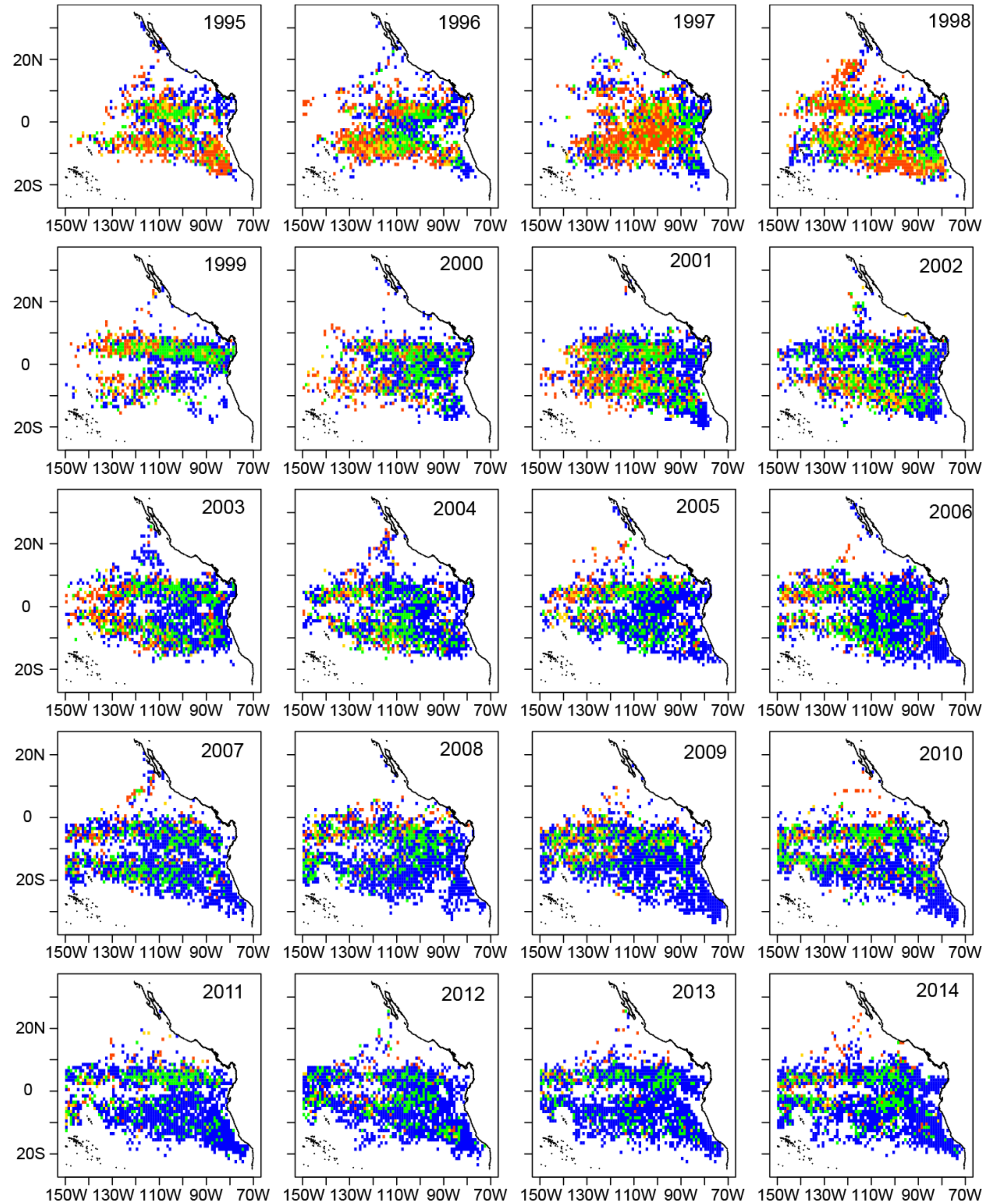

FIGURE 1c. Average bycatch per set in floating-object sets, in numbers, of large (> 150 cm total length) silky sharks, 1995-2014. Blue: 0 sharks per set, green: ≤ 1 shark per set; yellow: 1-2 sharks per set; red: > 2 sharks per set.

FIGURA 1c. Captura incidental media por lance en lances sobre objetos flotantes, en número, de tiburones sedosos grandes (> 150 cm de talla total), 1995-2014. Azul: 0 tiburones por lance, verde: ≤ 1 tiburones por lance; amarillo: 1-2 tiburones por lance; rojo: > 2 tiburones por lance.

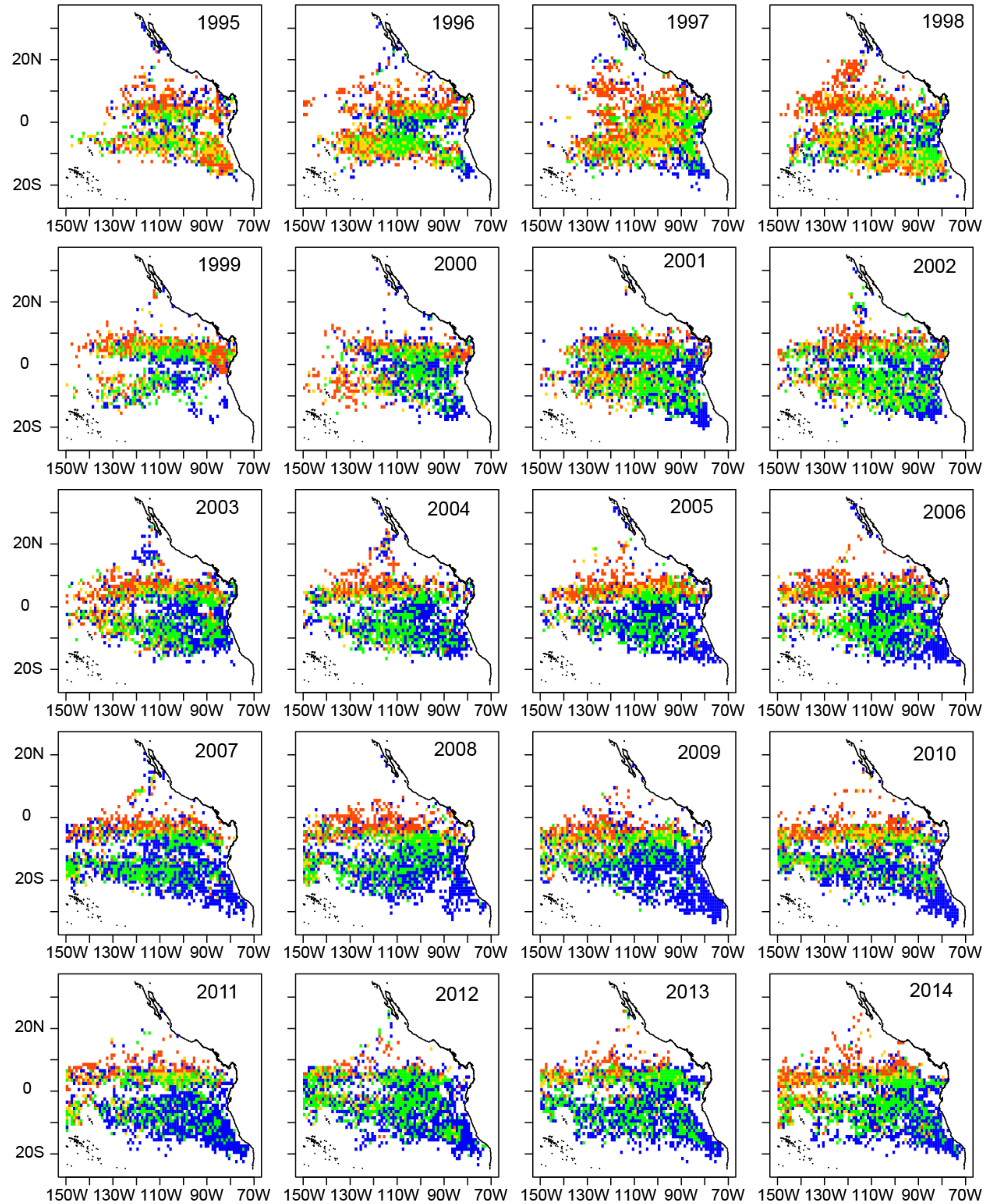

FIGURE 1d. Average bycatch per set in floating-object sets, in numbers, of all silky sharks, 1995-2014. Blue: 0 sharks per set, green: ≤2 shark per set; yellow: 2-5 sharks per set; red: >5 sharks per set.

FIGURA 1d. Captura incidental media por lance en lances sobre objetos flotantes, en número, de todos tiburones sedosos, 1995-2014. Azul: 0 tiburones por lance, verde: ≤ 2 tiburones por lance; amarillo: 2-5 tiburones por lance; rojo: > 5 tiburones por lance.

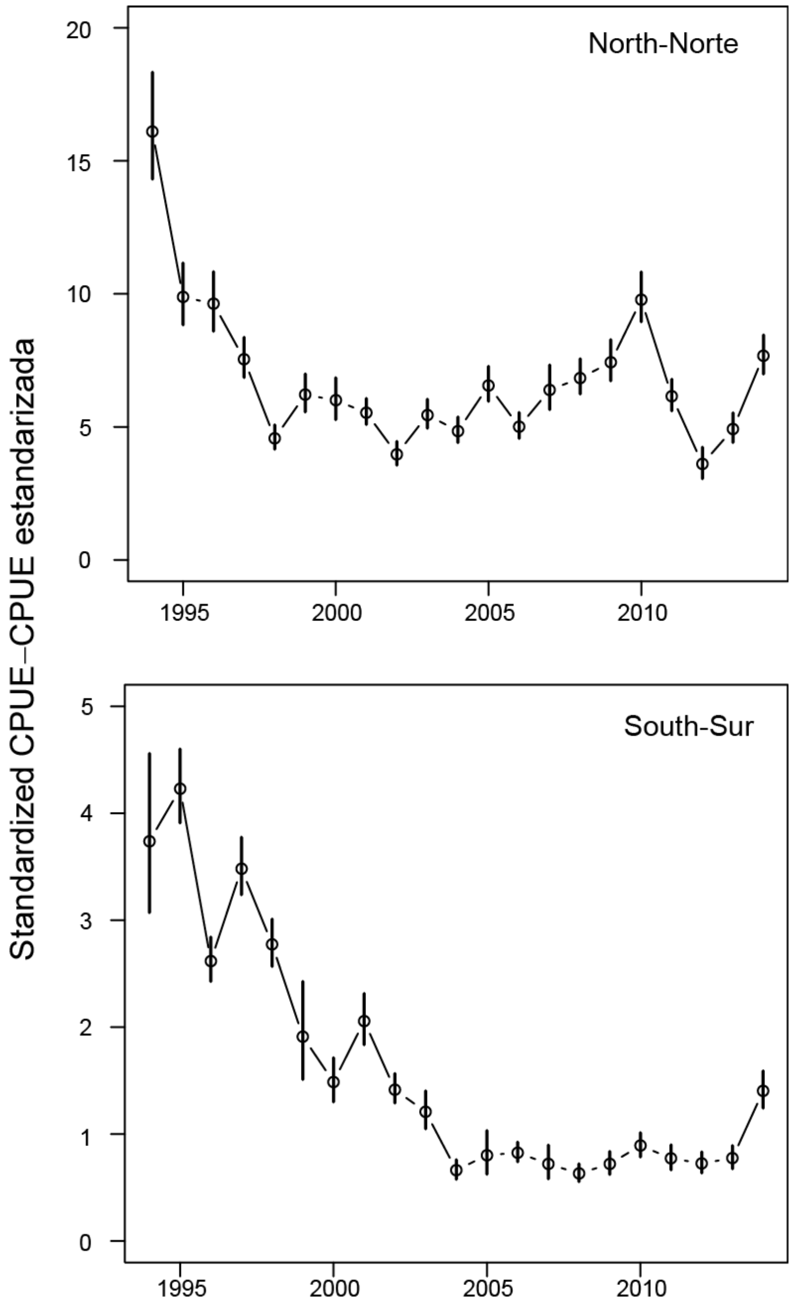

FIGURE 2. Standardized catch-per-unit-effort (CPUE, in number of sharks per set) of all silky sharks in floating-object sets for northern (top) and southern (bottom) EPO stocks. Approximate 95% pointwise confidence intervals were computed by resampling from the posterior distribution of estimated GAM coefficients, assuming known smoothing and scale parameters.

FIGURA 2. Captura por unidad de esfuerzo (CPUE, en número de tiburones por lance) estandarizada de todos los tiburones en lances sobre objetos flotantes de las poblaciones del OPO del norte (arriba) y sur (abajo). Se computaron los intervalos puntuales de confianza aproximados de 95% mediante un remuestreo de la distribución posterior de los coeficientes estimados del MAG, suponiendo parámetros de escala y suavización conocidos.

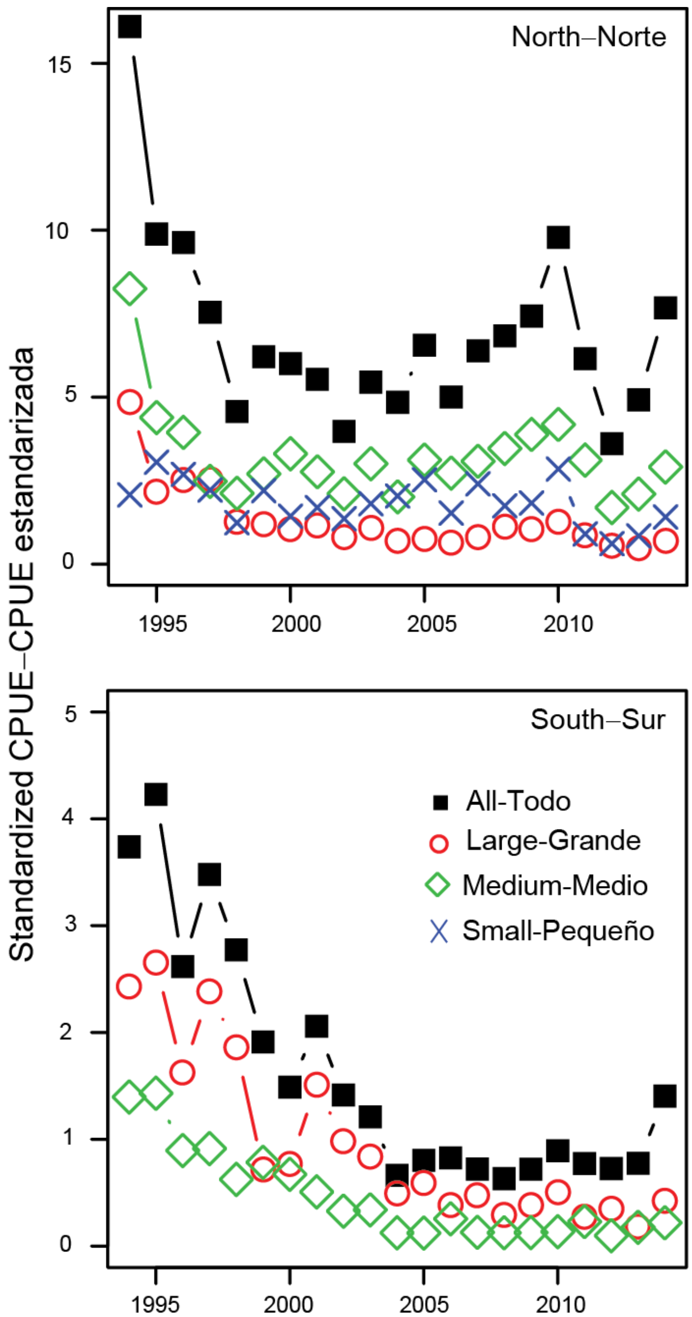

FIGURE 3a. Standardized catch-per-unit-effort (CPUE; in numbers of sharks per set) in sets on floating objects (OBJ) of silky sharks of different size classes (small, medium, large) and all silky sharks for northern (top) and southern (bottom) EPO stocks. No index was computed for small silky sharks in the south due to model instability caused by the low levels of bycatch in recent years; see Figure 1a.

FIGURA 3a. Captura por unidad de esfuerzo (CPUE, en número de tiburones por lance) estandarizada en lances sobre objetos flotantes (OBJ) de tiburones sedosos de distintas clases de talla (pequeño, mediano, grande) y todos los tiburones sedosos correspondiente a las poblaciones del norte (arriba) y sur (abajo) en el OPO. No se computó un índice para los tiburones sedosos pequeños en el sur debido a la inestabilidad del modelo causada por los bajos niveles de captura incidental en los años recientes (Figura 1a).

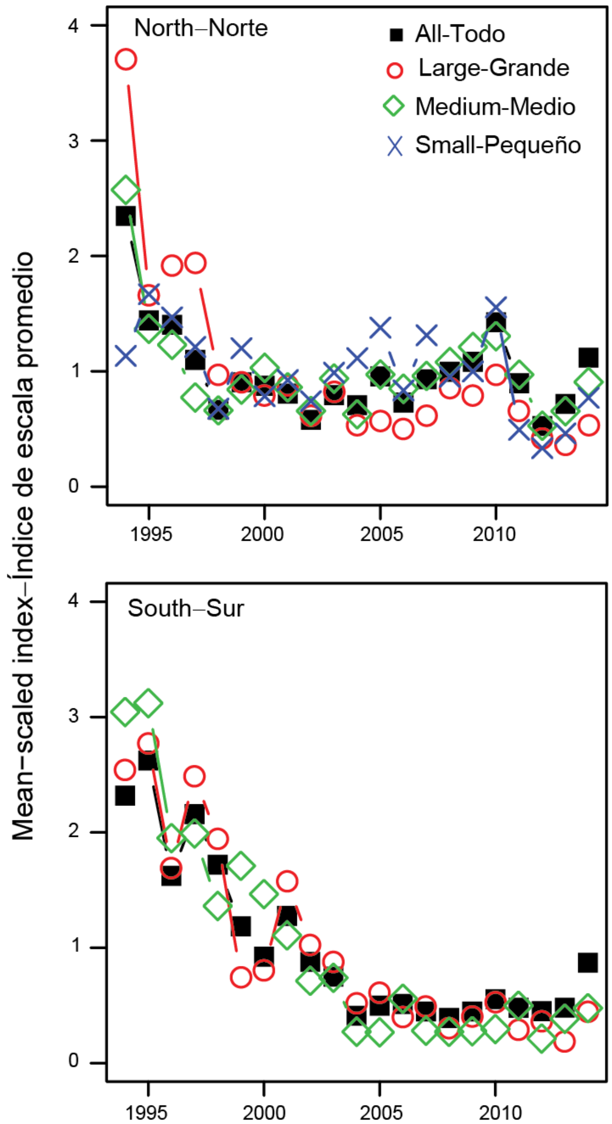

FIGURE 3b. Mean-scaled standardized catch-per-unit-effort in floating-object sets (CPUE-OBJ) (from Figure 3a) for silky sharks of different size classes (small, medium, large) and all silky sharks for the northern (top) and southern (bottom) EPO stocks. No index was computed for small silky sharks in the south due to model instability caused by the low levels of bycatch in recent years (Figure 1a).

FIGURA 3b. Captura por unidad de esfuerzo estandarizada en lances sobre objetos flotantes (CPUE-OBJ) en escala al promedio de tiburones sedosos de distintas clases de talla (pequeño, mediano, grande) y todos los tiburones sedosos correspondiente a las poblaciones del norte (arriba) y sur (abajo) en el OPO. No se computó un índice para los tiburones sedosos pequeños en el sur debido a la inestabilidad del modelo causada por los bajos niveles de captura incidental en los años recientes (Figura 1a).

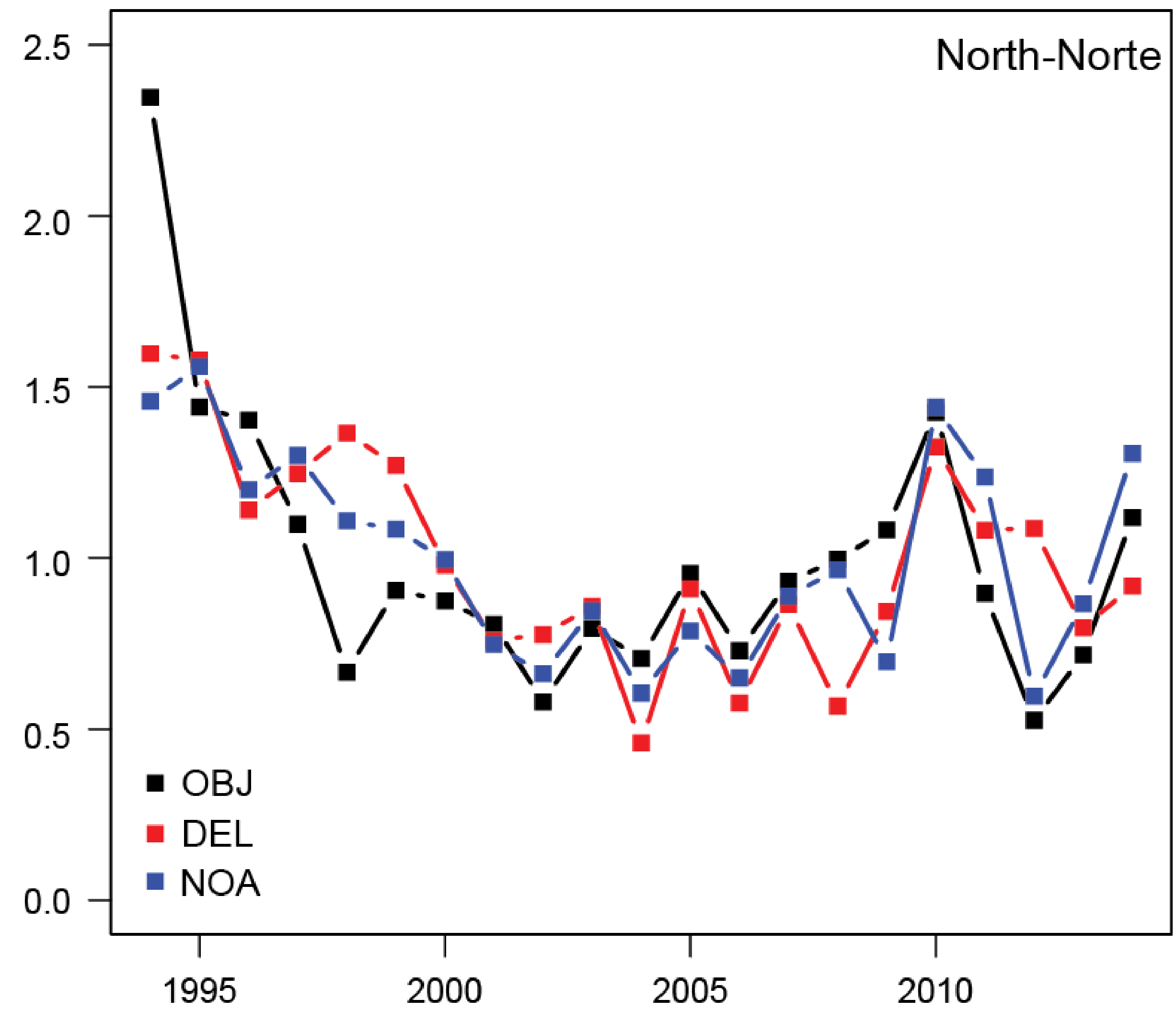

FIGURE 4. Comparison of stock status indicators (SSIs) for the northern silky shark produced for different purse-seine set types (floating-object (OBJ), dolphin (DEL), unassociated (NOA)).
FIGURA 4. Comparación de indicadores de condición de población (SSI) para el tiburón sedoso del norte producidos para distintos tipos de lance cerquero (objeto flotante (OBJ), delfín (DEL), no asociado (NOA)).

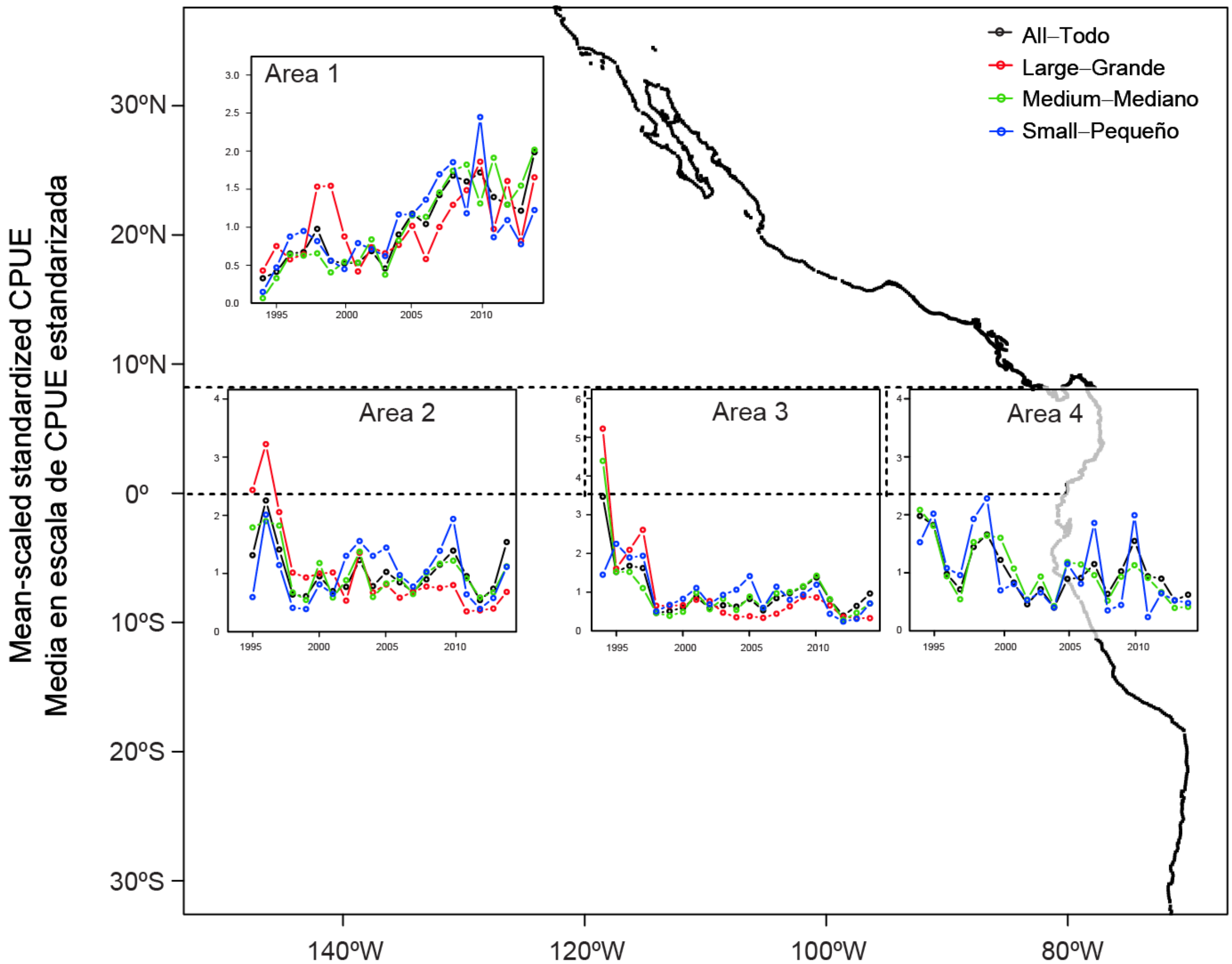

FIGURE 5. Mean-scaled standardized CPUE for silky sharks in the north, by sub-area. The black horizontal dashed lines show the locations of the four sub-areas: Area 1 (north of 8°N); Area 2 (0°-8°N and 120°-150°W); Area 3 (0°-8°N and 95°-130°W), and Area 4 (0°-8°N, from the coast to 95°W). A trend was not computed for large sharks in Area 4 because of model instability.

FIGURA 5. CPUE estandarizada en escala al promedio de tiburones sedosos en el norte, por subárea. Las líneas de trazos negras horizontales indican la posición de las cuatro subáreas: Área 1 (al norte de 8°N); Área 2 (0°-8°N y 120°-150°O); Área 3 (0°-8°N 95°-130°O), y Área 4 (0°-8°N, desde la costa hasta 95°O). No se computó una tendencia para los tiburones grandes en el Área 4 debido a inestabilidad en el modelo.