Updated stock status indicators for silky sharks in the eastern Pacific Ocean (1994-2016), with oceanographic considerations

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Background and presentation summary

- An attempt in 2013 to assess the status of the silky shark (*Carcharhinus falciformis*) using conventional stock assessment models was severely hindered by major uncertainties in the fishery data.
- Because a conventional assessment was not possible, stock status indices are computed.
- Indices updated through 2016 for:
  - Floating-object sets, all silky sharks and by shark size category;
  - Floating-object sets, by sub-area within the north EPO;
  - Presence/absence indices for dolphin/unassociated sets for the north EPO.
- Several other indices are compared to the north EPO indices:
  - Preliminary WCPO silky shark index, associated sets;
  - Index of oceanographic variability for the Pacific Ocean.

Data and Methods

EPO floating-object sets

- Purse-seine observer data, 1994-2016.

Floating-object sets

- Standardized catch-per-set (CPS) trends estimated by:
  - area (north and south of the equator, and sub-areas within the north);
  - All silky sharks, and by total length (TL) category:
    - Small silky (< 90 cm TL)
    - Medium silky (90-150 cm TL)
    - Large silky (> 150 cm TL)
- Model for CPS standardization
  - Zero-inflated negative binomial generalized additive model (number of sharks per set)
  - Predictors:
    - Year (factor);
    - Smooth terms: latitude, longitude, time of the set, day of the year;
    - Linear terms: net depth, floating-object depth, SST, log(non-silky bycatch), log(tuna catch), proxies for local object density.
- Indices are data-weighted indices.

Data and Methods

EPO Dolphin and unassociated sets

- Standardized presence/absence index for the northern EPO.

- Model used for standardization
  - Logistic regression model (for presence/absence of any silky sharks in the set)
  - Predictors:
    - Year (factor);
    - Smooth terms: latitude, longitude, time of the set, day of the year;
    - Linear terms: net depth, SST, duration of encirclement (and, duration of chase for dolphin sets).

- Indices are also data-weighted.

Data and Methods

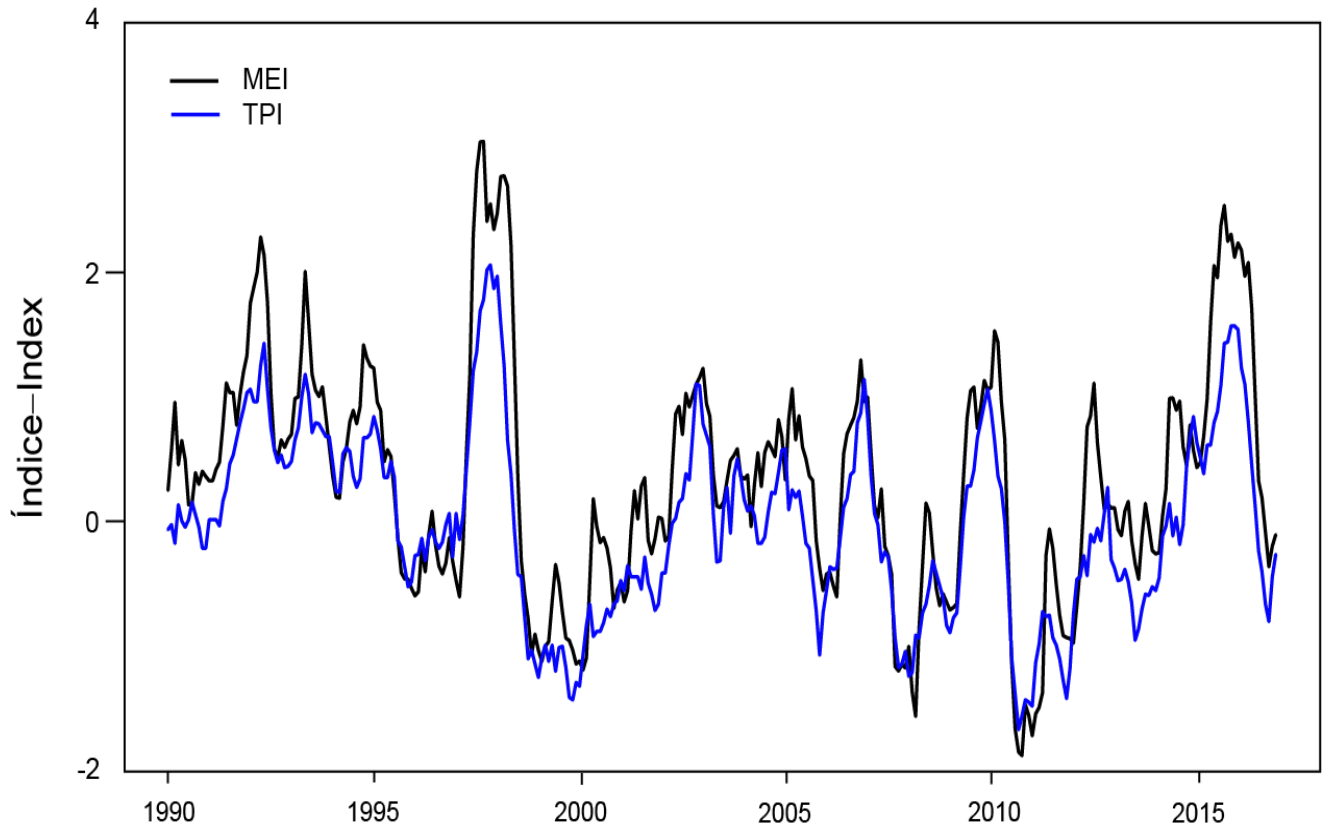
Preliminary Western and Central Pacific (WCPO) index

- Access to WCPO purse-seine observer data made possible through collaboration with WCPFC, initiated to support an ABNJ Pacific-wide silky shark assessment.
- Associated sets, 2004-2015, 145°E-180°E and 10°S-5°N.
- The trend was estimated using the same methods as used for the EPO floating-object set index.
- Predictors:
  - factors: year, vessel flag, association type;
  - smooth terms: latitude, longitude, time of set and month;
  - linear terms: log(tuna catch), log(proxy for local object density).
- WCPO index is compared to north EPO floating-object set trends for both small and medium silky sharks.

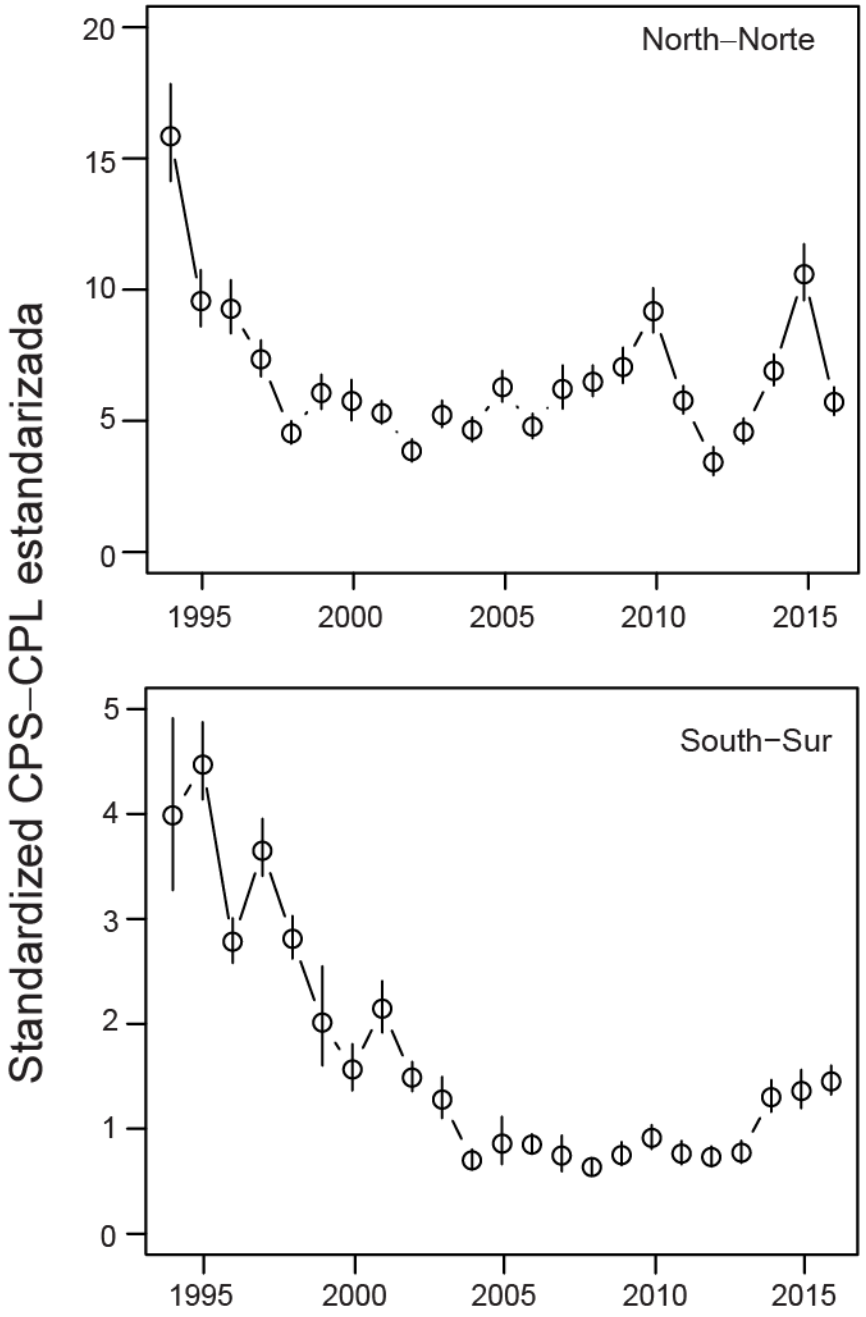
Data and Methods

Index of variability in oceanographic conditions

- The Indo-Pacific Tripole (TPI).
- The TPI is a measure of variability in sea-surface temperature anomalies that captures low and high-frequency links between ocean basins, which influence tropical Pacific oceanographic conditions.
- The TPI shows similarities to other environmental indices, e.g., the Multivariate El Niño-Southern Oscillation Index (MEI).



MEI: https://www.esrl.noaa.gov/psd/enso/mei/index.html
TPI: https://www.esrl.noaa.gov/psd/data/timeseries/IPOTPI/



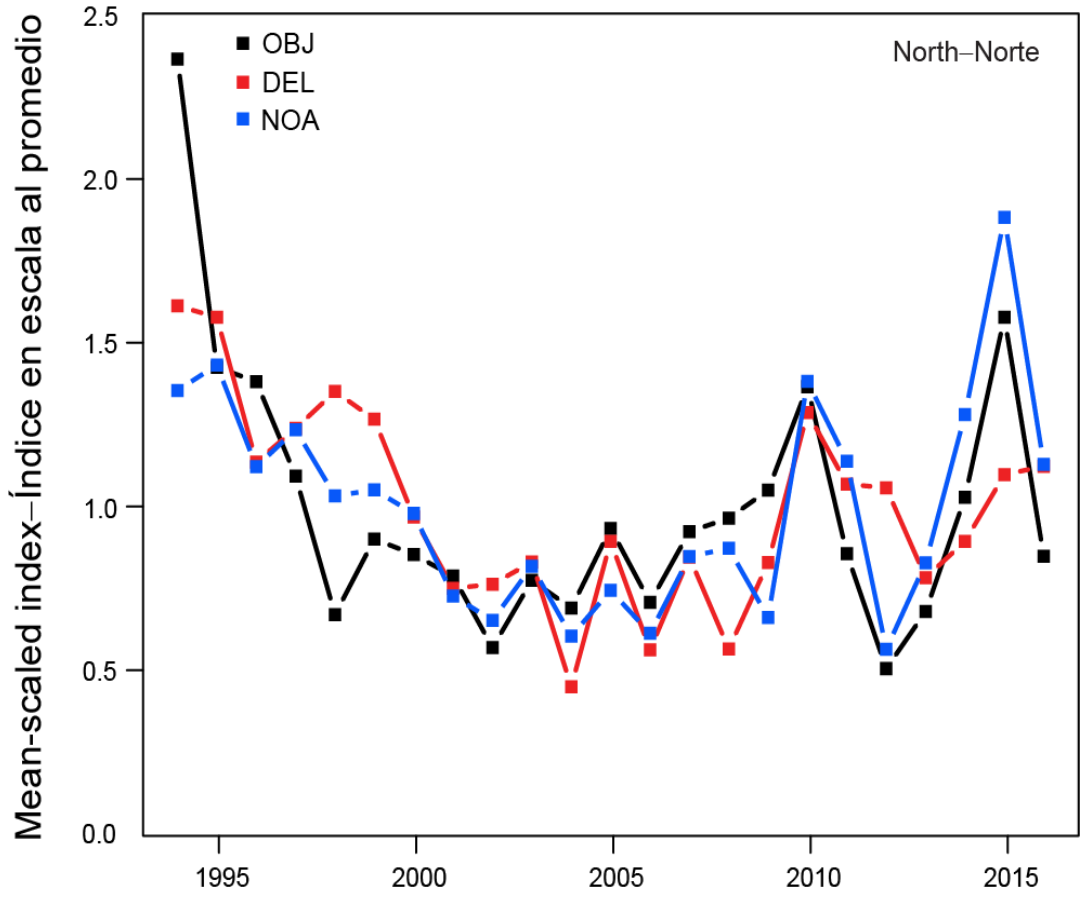
All silky sharks, EPO

Northern EPO:

- Sharp decline, 1994-1998;
- Low level and relatively stable, 1999-2009;
- Sharp decrease then increase, 2010-2015;
- Another sharp decrease in 2016.

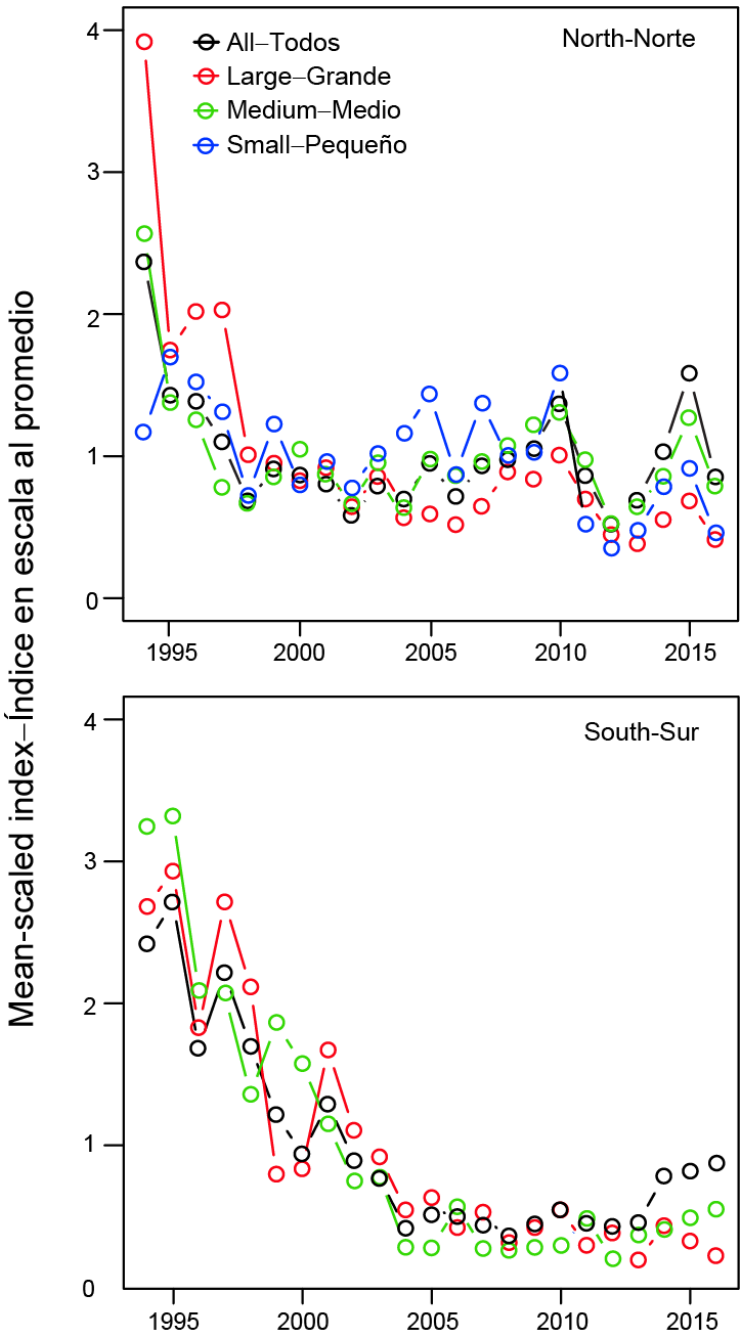
Southern EPO:

- Sharp decline, 1994-2004;
- Low level and relatively stable, 2005-2013;
- Slight increase 2013 to 2014;
- Little change 2014-2016.



All silky sharks, EPO

Northern EPO:
Presence/absence trends for dolphin and unassociated sets are, overall, similar to the floating-object set index.

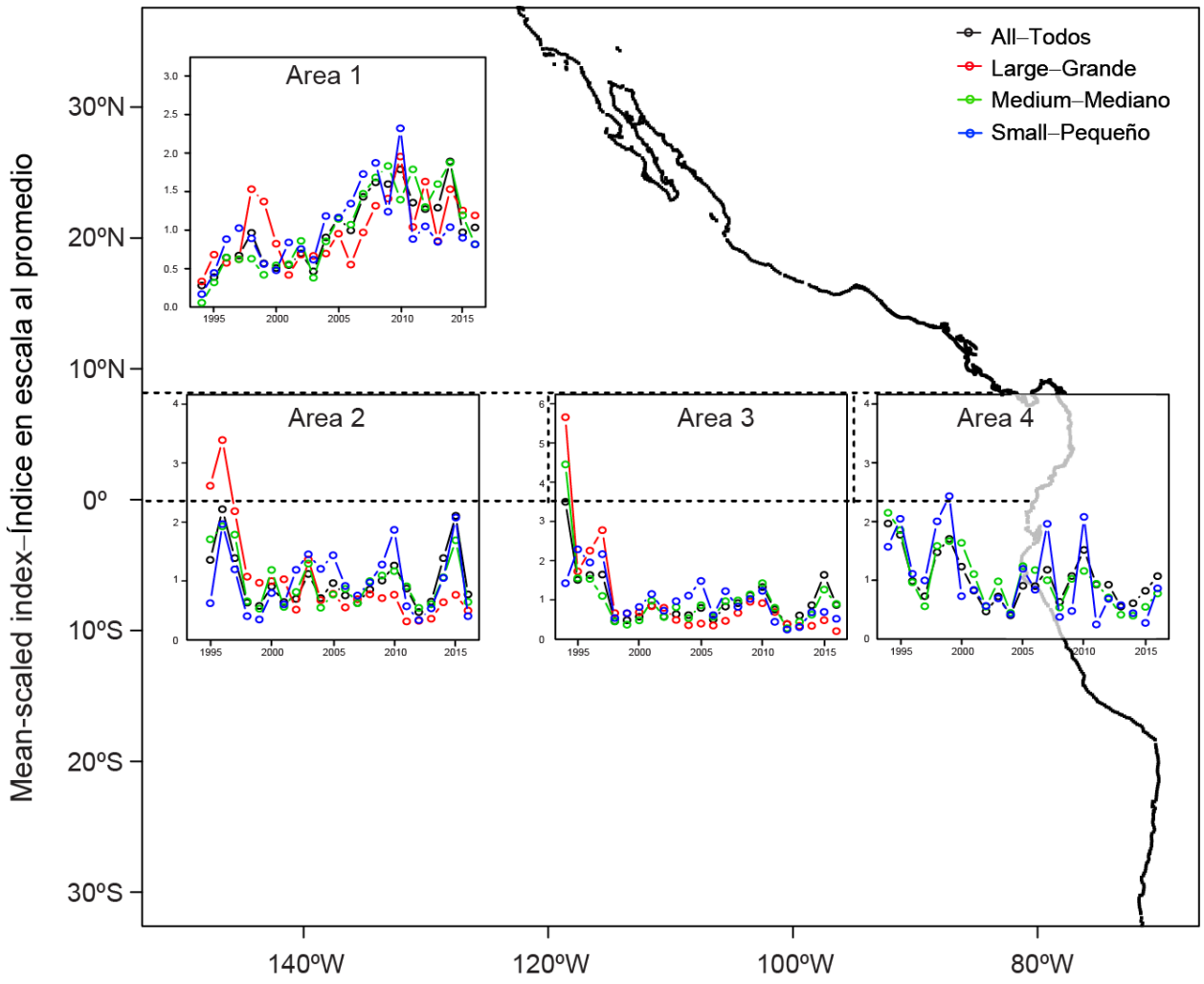


Northern EPO

- Long-term trends by size are similar;
- Year-to-year changes of small-shark index differ somewhat prior to 2009;
- Expected if small-shark index is a proxy for recruitment;
- However, similarity between all three indices from 2009;
- Mechanisms acting on the different size categories are more complex.

Southern EPO

- Recent increase in total index may be due to increase of small/medium sharks along western boundary;
- Trend for small sharks not computed due to low levels of bycatch.

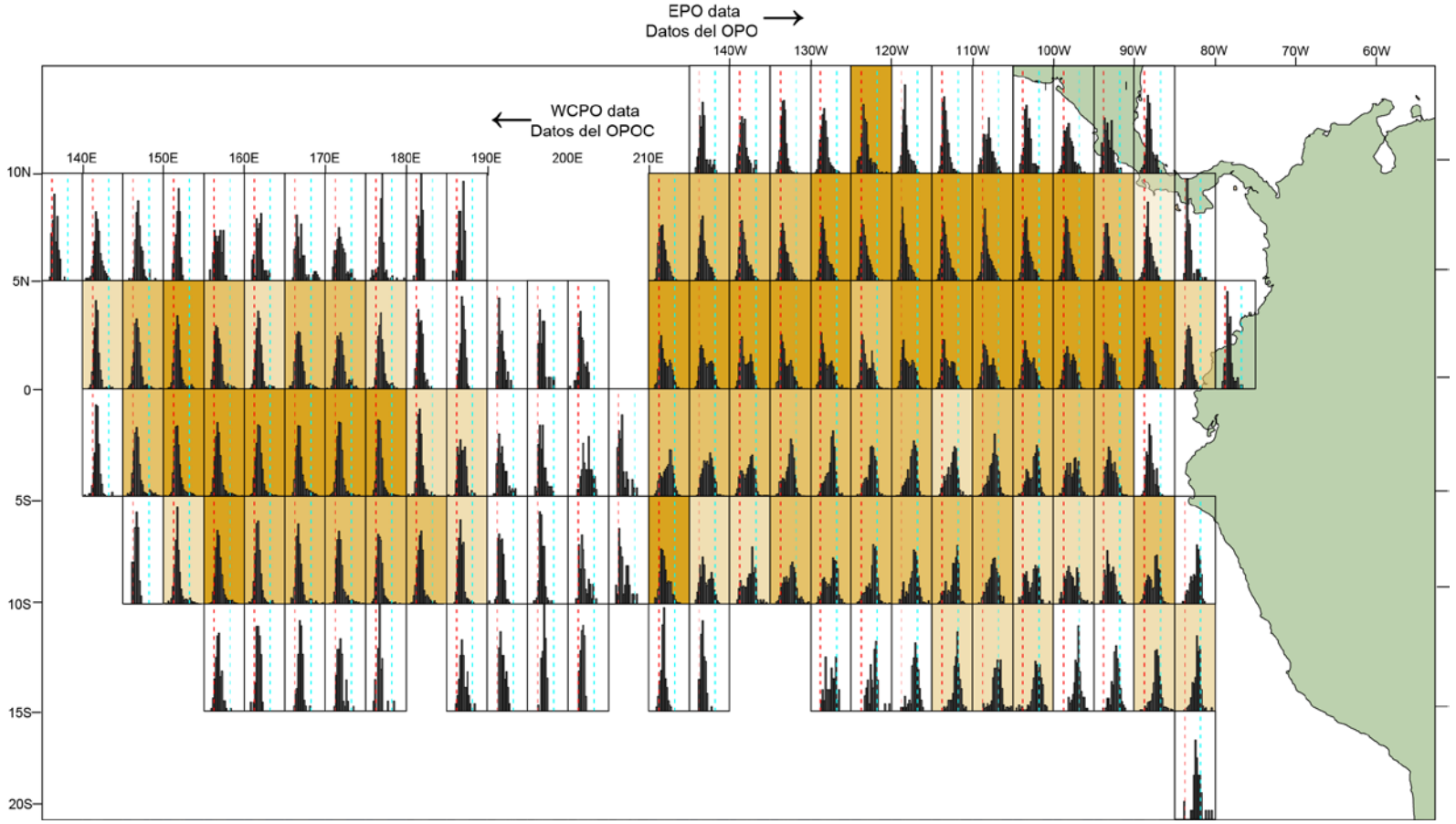


Spatial patterns in north EPO trends

- Different trends by sub-area.
- Recent decrease is mostly occurring in offshore equatorial waters.

Comparison EPO and WCPO trends

Size composition data, WCPO associated sets and EPO floating-object sets

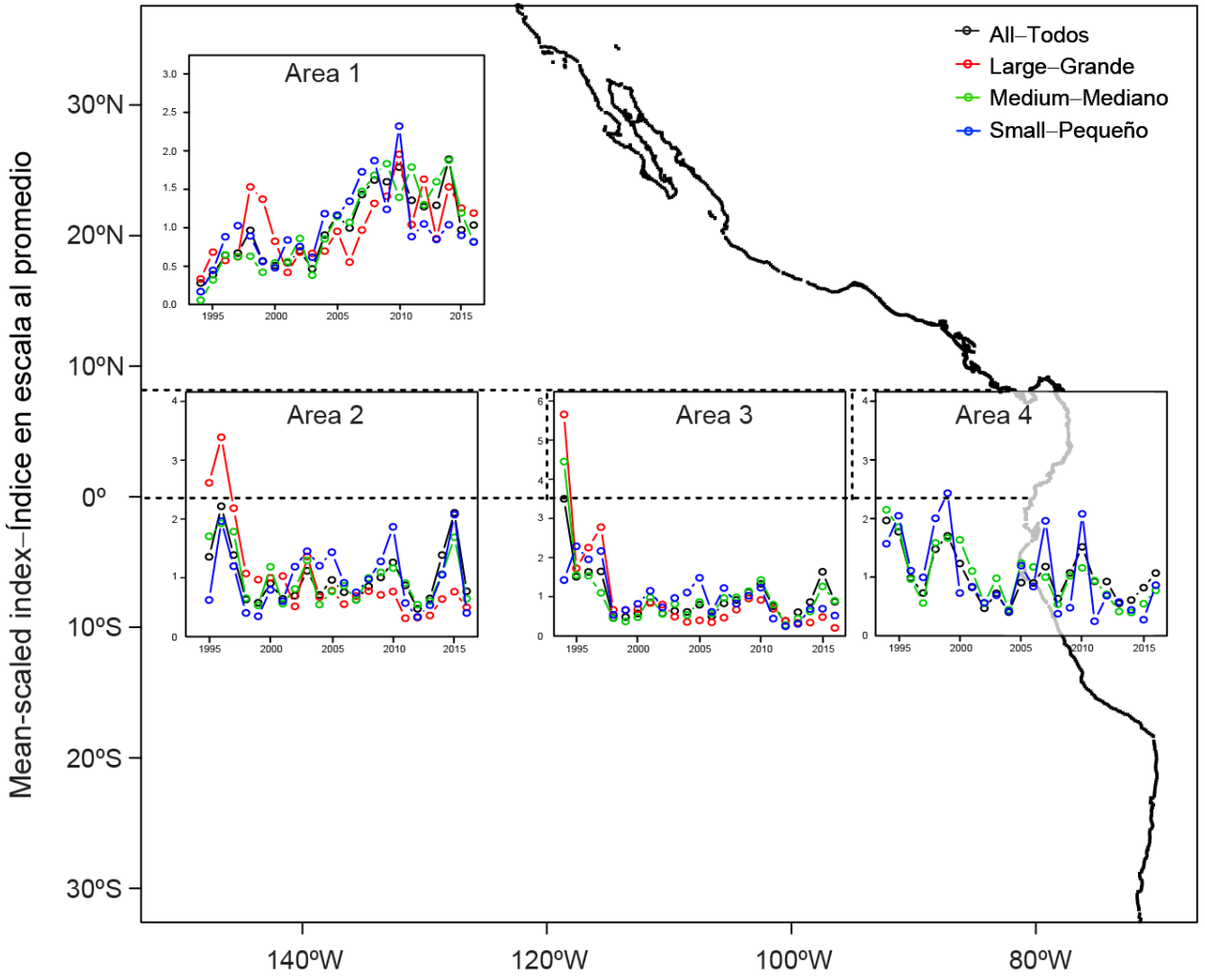


Comparison EPO and WCPO trends

Preliminary size composition comparison:

- The size composition data are skewed towards smaller-sized individuals for WCPO and north EPO.
- Modes of the length distributions for WCPO, by 5° area, ranged from 67-110 cm FL, with the median at 83 cm FL, about 10 cm above the upper limit of the EPO ‘small’ category (72 cm FL).
- For 90% of sharks sampled in the WCPO, fork length was below the upper length limit of the EPO ‘medium’ category.
- Range of sampled lengths from WCPO largely overlaps with the ‘small’ and ‘medium’ categories of the EPO data.
- Therefore, the WCPO trend was compared to trends for both small and medium sharks for floating-object sets for the north EPO, by sub-area.

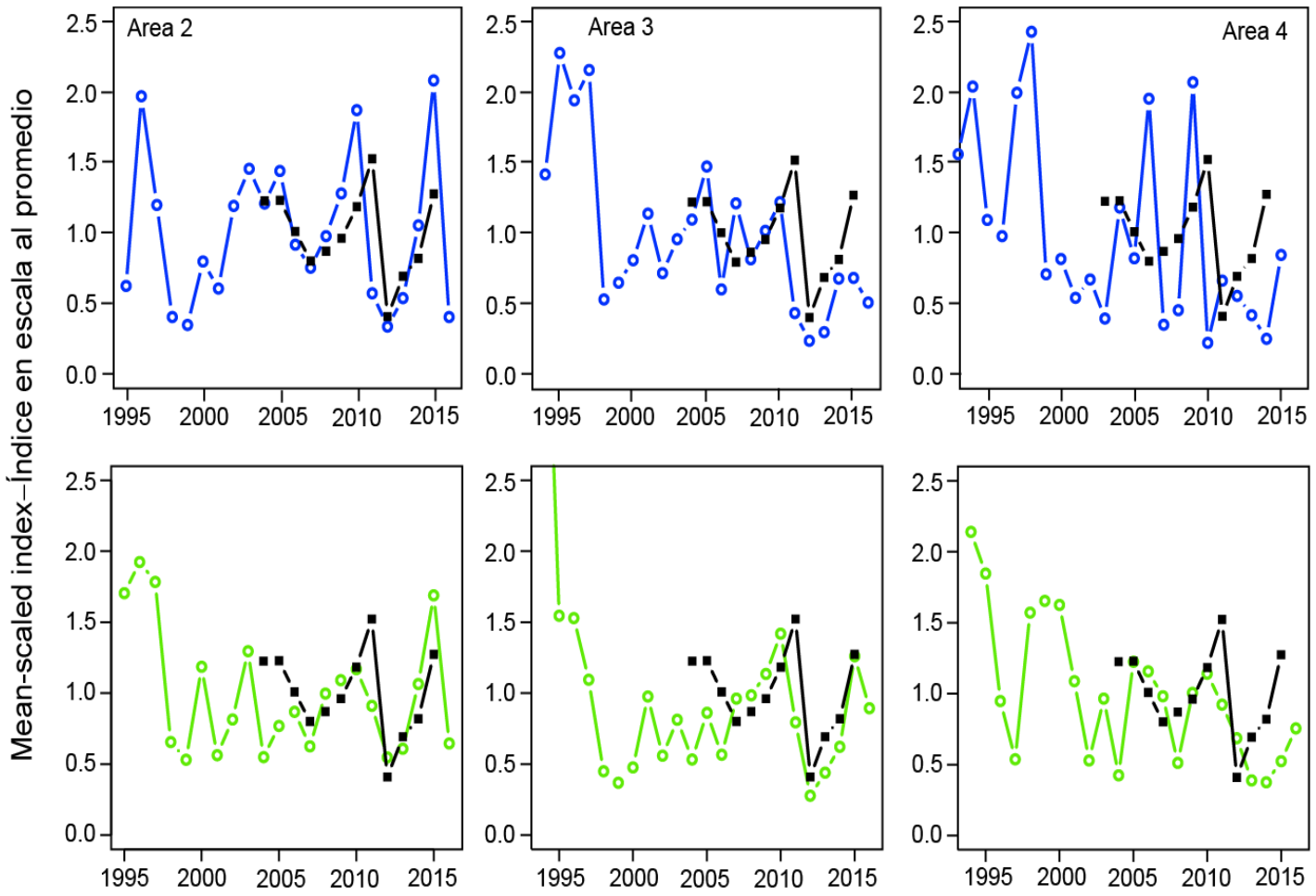
North EPO trends, by sub-area



Comparison EPO and WCPO trends

WCPO (black line) and EPO small silky sharks

WCPO (black line) and EPO medium silky sharks



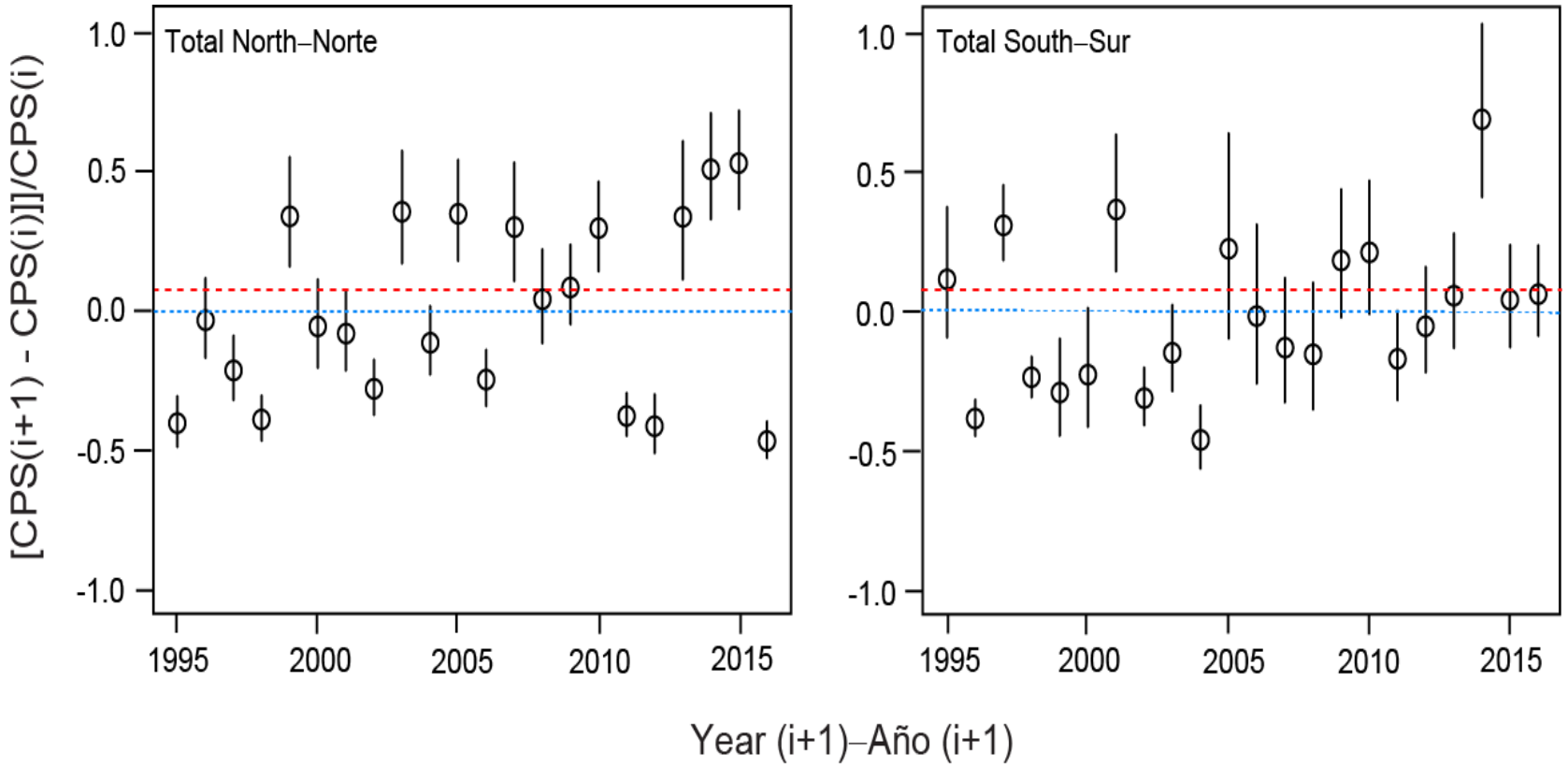
- Similarity between WCPO index and EPO small/medium indices in offshore areas (Areas 2-3).
- WCPO and EPO indices appear less similar for the coastal area (Area 4).

Changes in abundance *versus* movement/changes in catchability

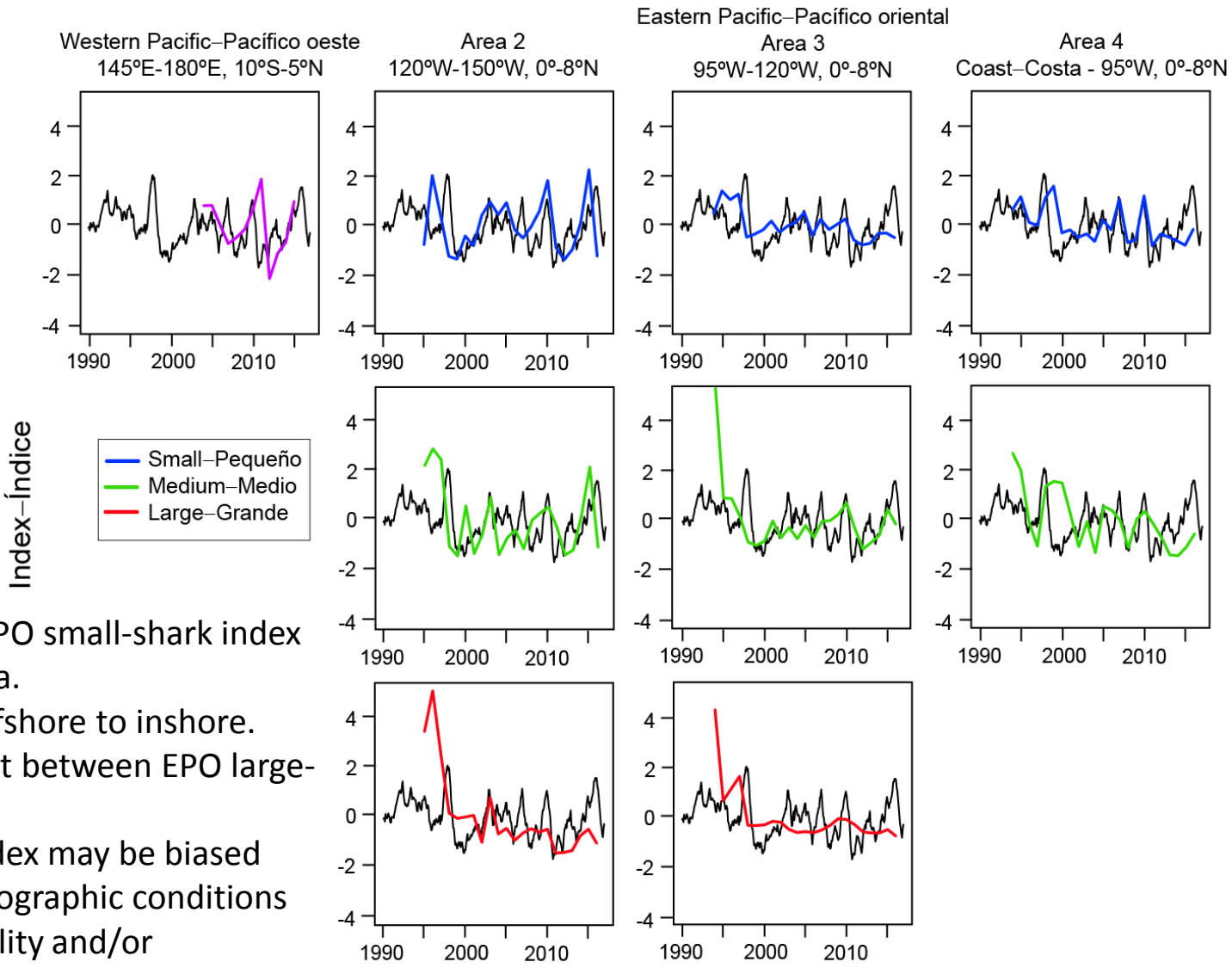
- Environmentally-driven population growth (via increased recruitment), movement, and availability to fishing gear are processes that might lead to similar trends in the indices for the WCPO and EPO, and among purse-seine set types within the EPO.
- However, the increases in the floating-object indices for all sharks in consecutive years, especially in the north EPO, are generally too large to attribute to population growth alone.

Changes in abundance *versus* movement/ changes in catchability

In many years, especially in north EPO, no overlap of upper confidence limit on the estimated finite rate of population increase for a virgin population (red line) and the lower confidence limit on the proportional change in the floating-object index from year to year.



Comparison north EPO, WCPO silky trends and the TPI (black line)



- Agreement between EPO small-shark index and TPI in offshore area.
- Agreement changes offshore to inshore.
- Perhaps less agreement between EPO large-shark index and TPI.
- North EPO all-shark index may be biased due to changing oceanographic conditions that influence catchability and/or movement.

Summary

- The northern EPO index for all silky sharks shows a large decrease in 2016 relative to 2015. In contrast, the southern EPO index for all silky sharks remains at about the 2014-2015 level.
- Recent changes in the north EPO indices may be due to changing oceanographic conditions that influence movement/catchability, as suggested by:
  - Similarity between north EPO small/medium/large shark indices from 2009;
  - Similarity of north EPO all-silky index and dolphin-set and unassociated-set indices;
  - Differences in trends of north EPO indices by sub-area;
  - Similarity between WCPO index and offshore equatorial small/medium north EPO indices;
  - Similarity between north EPO small-shark and the TPI.
- Further analysis, in collaboration with WCPFC, will be necessary to quantitatively evaluate the origin and magnitude of this potential bias.
- The IATTC staff reiterates its previous observation that improving shark fishery data collection for other fisheries in the EPO is critical.