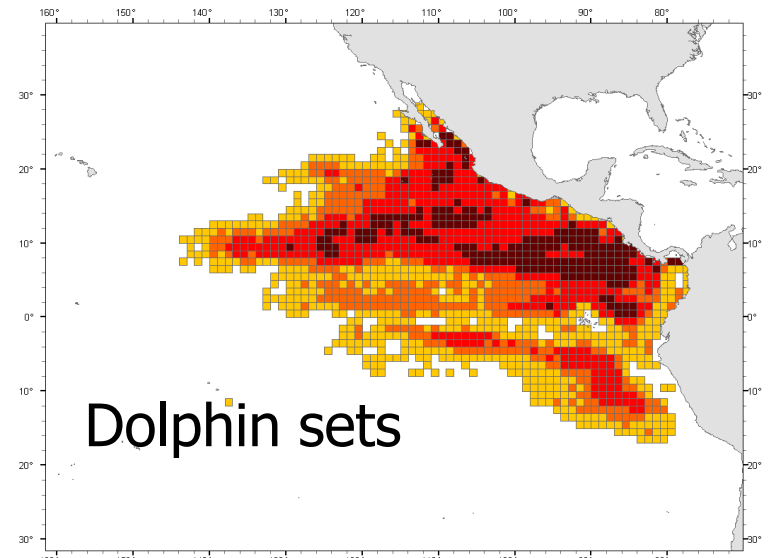
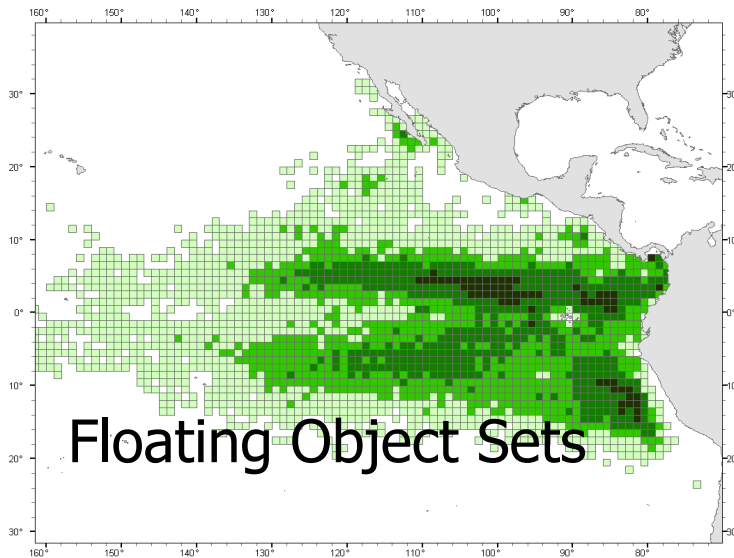


Purse-seine estimates

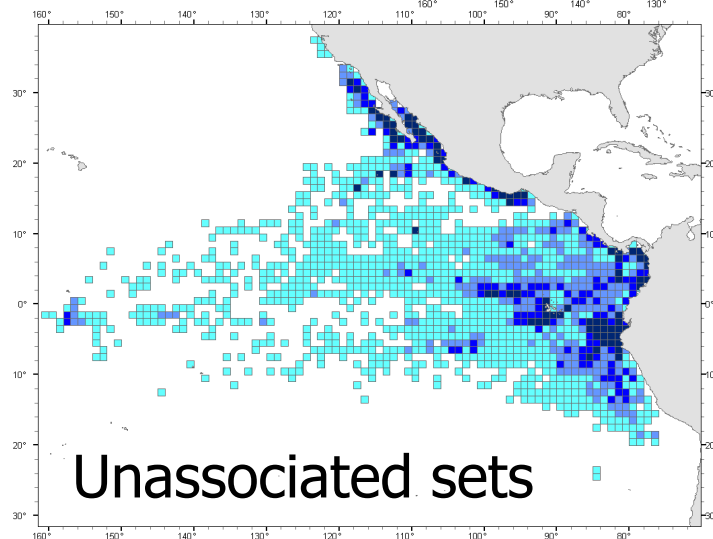


Tuna purse seine fishery: spatial distribution of fishing effort

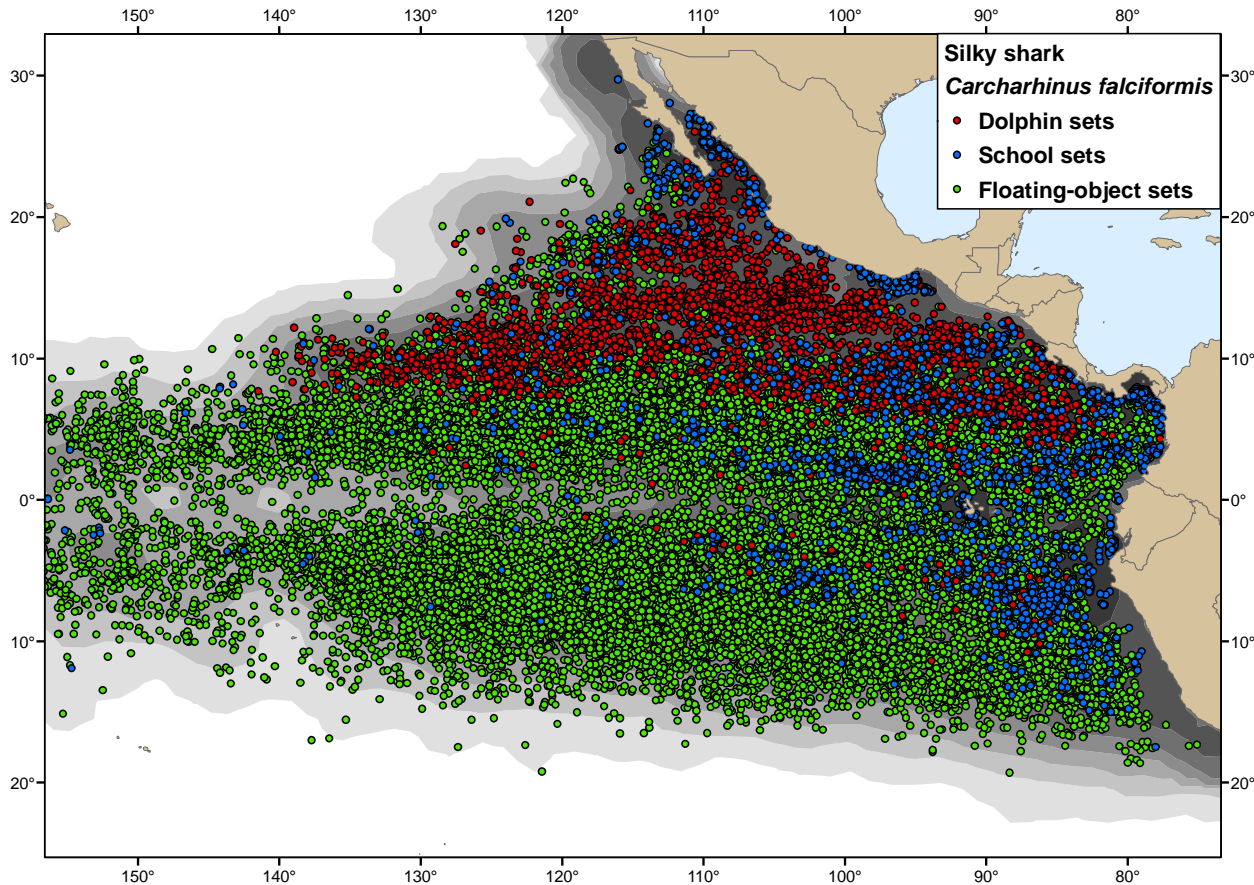


1993 - 2003

No. Sets



Tuna purse seine fishery: spatial distribution of silky shark bycatch



1993-present



Effort

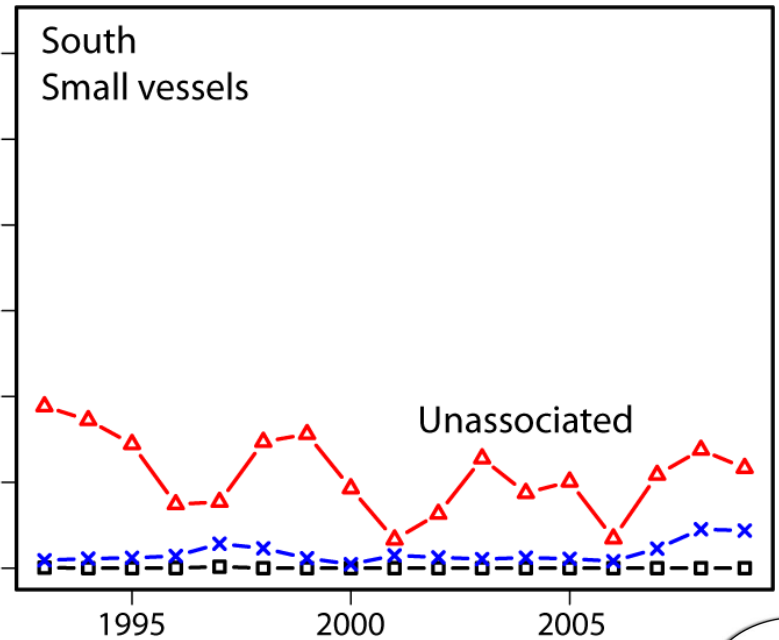
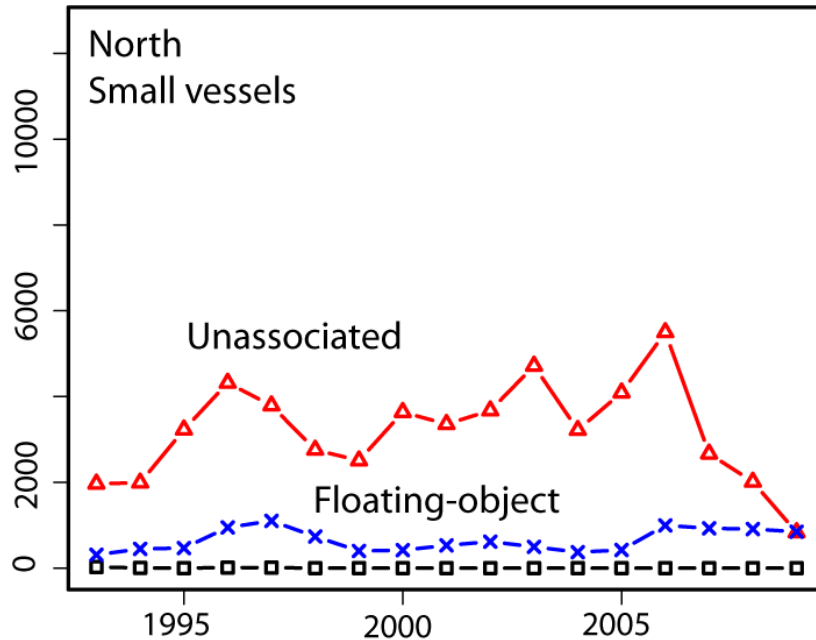
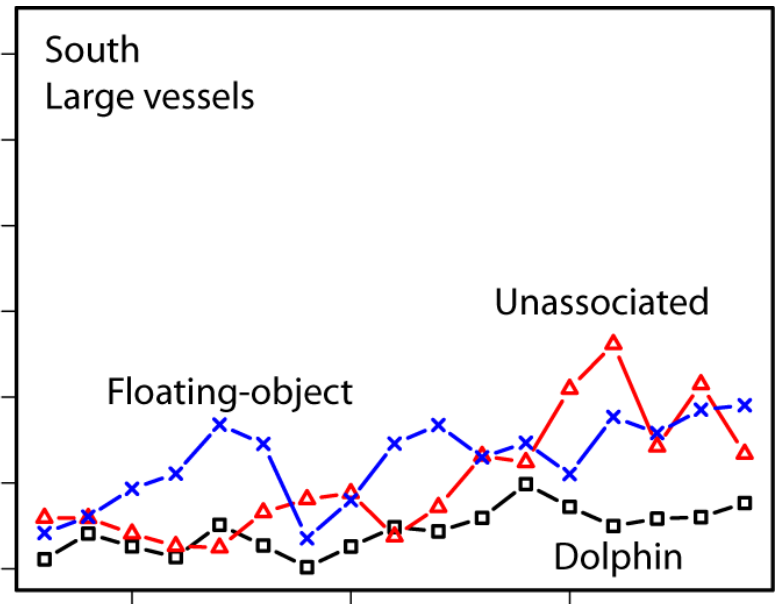
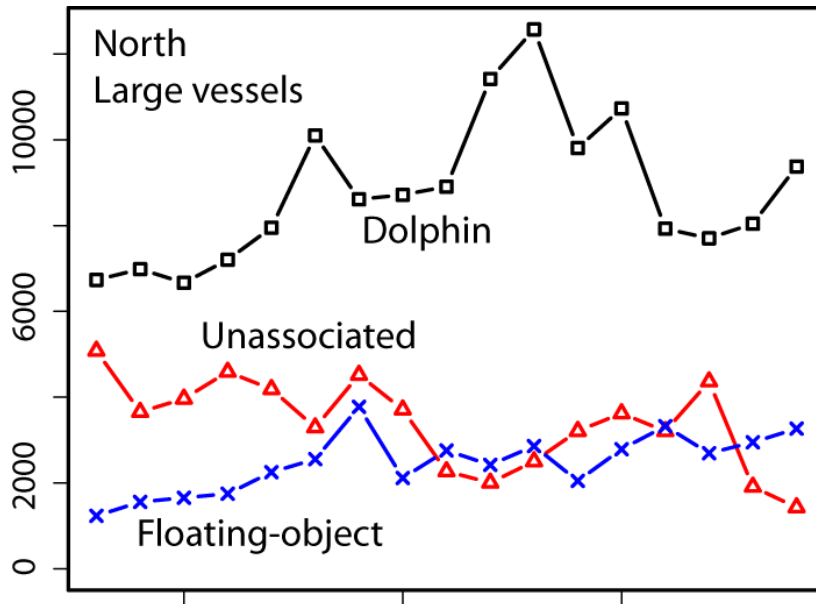
- Number of purse-seine sets by vessel size class:
 - Large vessels: >363 t fish-carrying capacity
 - Small vessels: ≤ 363 t fish-carrying capacity
- Data on sets by large vessels are collected by observers (or from vessel logbooks when observer data unavailable).
- Data on sets by small vessels are obtained from logbooks (corrected for coverage).

(Both available in IATTC Fisheries Status Reports, Table A-7)

- Prorated to north and south using proportions computed from observer and logbook data.



Number of purse-seine sets



Year



Observer data for shark bycatch

- Shark bycatch data collected by observers aboard large purse-seine vessels since 1993.
- Observer coverage for non-mammal bycatch has increased from ~40% in 1993 to 100% in 2009.
- Bycatch amounts recorded by species group and size category:
 - Species groups: blacktip, silky, oceanic whitetip, hammerheads, other species, unidentified.
 - Size categories: Small (<90cm TL), medium (90-150 cm TL), large (> 150 cm TL).
 - Amounts recorded in numbers or weight; weights converted to numbers.
- Ancillary information recorded on fishing operations and the environment.



Observer data

- Improvements to bycatch data undertaken since 2005*:
 - better species resolution;
 - detailed length and sex information collected;
 - bycatch only recorded in numbers;
 - additional data collected to check identifications for some species (e.g., silky).

- Recovery of species identifications from observer notes (where possible) for data collected prior to 2005*.

* Román-Verdesoto, M. and Orozco-Zöller, M. 2005. IATTC Data Report 11; Román *et al.* 2005. PFRP 10 (3): 4-5.



Species identification

- The problem: the dominant species recorded by observers prior to 2005 was the “blacktip” shark; however, *Carcharhinus limbatus* is a coastal/insular species.
- Likely source of the confusion: fishermen refer to the silky shark (*C. falciformis*) as a “punta negra” (“blacktip” in Spanish).
- In spite of training, it appears that observers took species identification cues from fishermen.



Species identification

- All information to this point suggests that these “blacktips” were very likely silky sharks:
 - A pilot study in 2001¹ found that:
 - “silky” sharks had characteristics of *C. falciformis*
 - “blacktip” sharks had characteristics of *C. falciformis*
 - Genetics information collected by observers since 2005 (J. Hyde, pers. comm.) indicates that animals identified as “silky” were silky sharks.
 - Since 2005, on average, bycatch of confirmed *C. limbatus* has been 0.92% of all shark bycatch (range: 0.01% – 2.39%).
- An predominance of the silky shark in EPO purse-seine bycatch has been observed previously².

¹ Román-Verdesoto and Orozco-Zöller 2005

² Au, D.W. 1991. Fishery Bulletin 89:343-354.



Species identification

Based on this information, we have made the following assumptions :

- Prior to 2005, all sharks recorded by observers as “blacktip” sharks were in fact silky sharks.
- From 2005, animals with characteristics consistent with the silky shark were silky sharks.



Total bycatch

Estimated separately by set type, north and south.
Estimated in numbers of sharks.

Large vessels:

Estimated separately for size categories: small, medium, large and unknown.

Total bycatch = bycatch-per-set (large vessels) x total sets (large vessels)

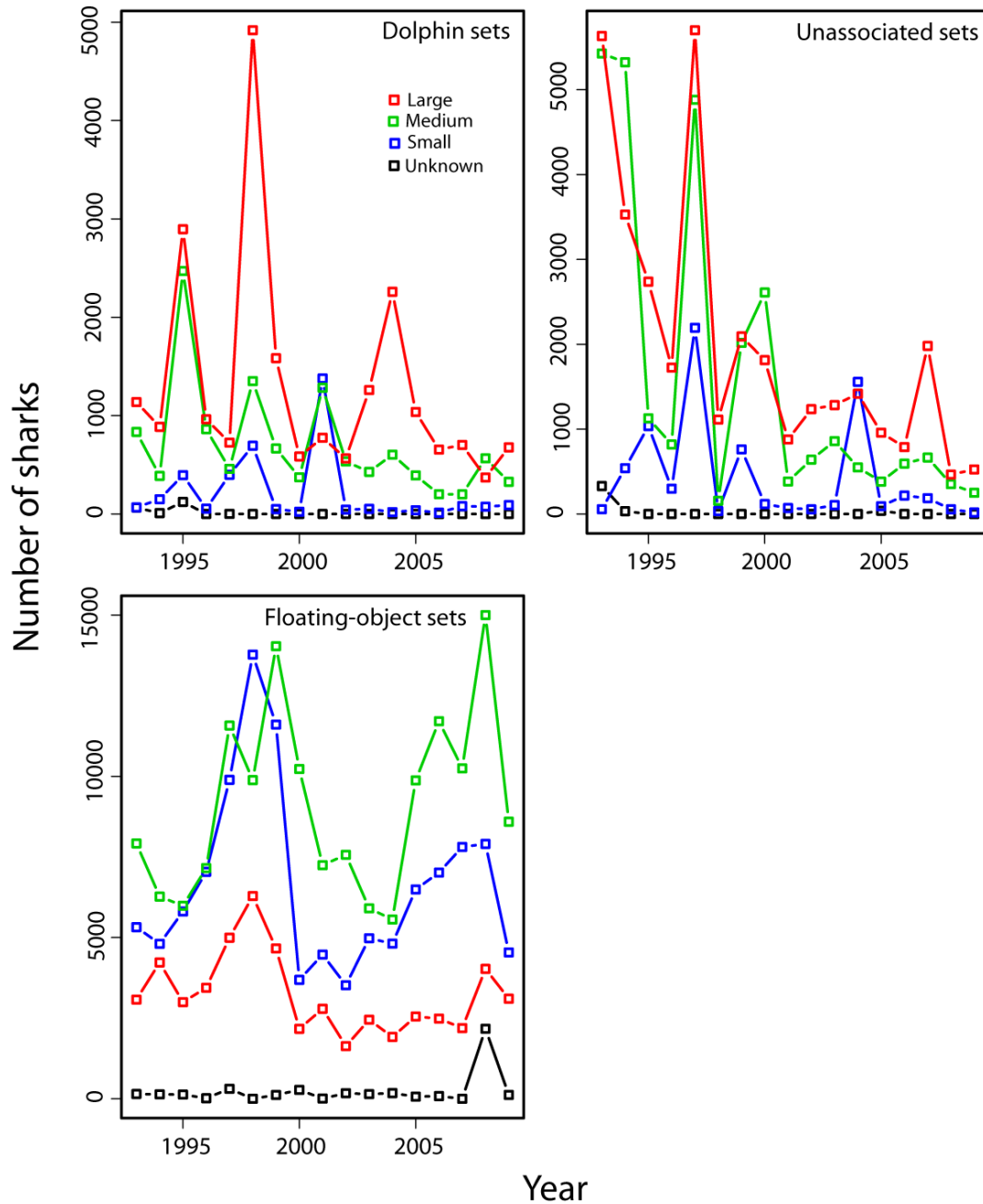
Small vessels:

Only estimated for all size categories combined.

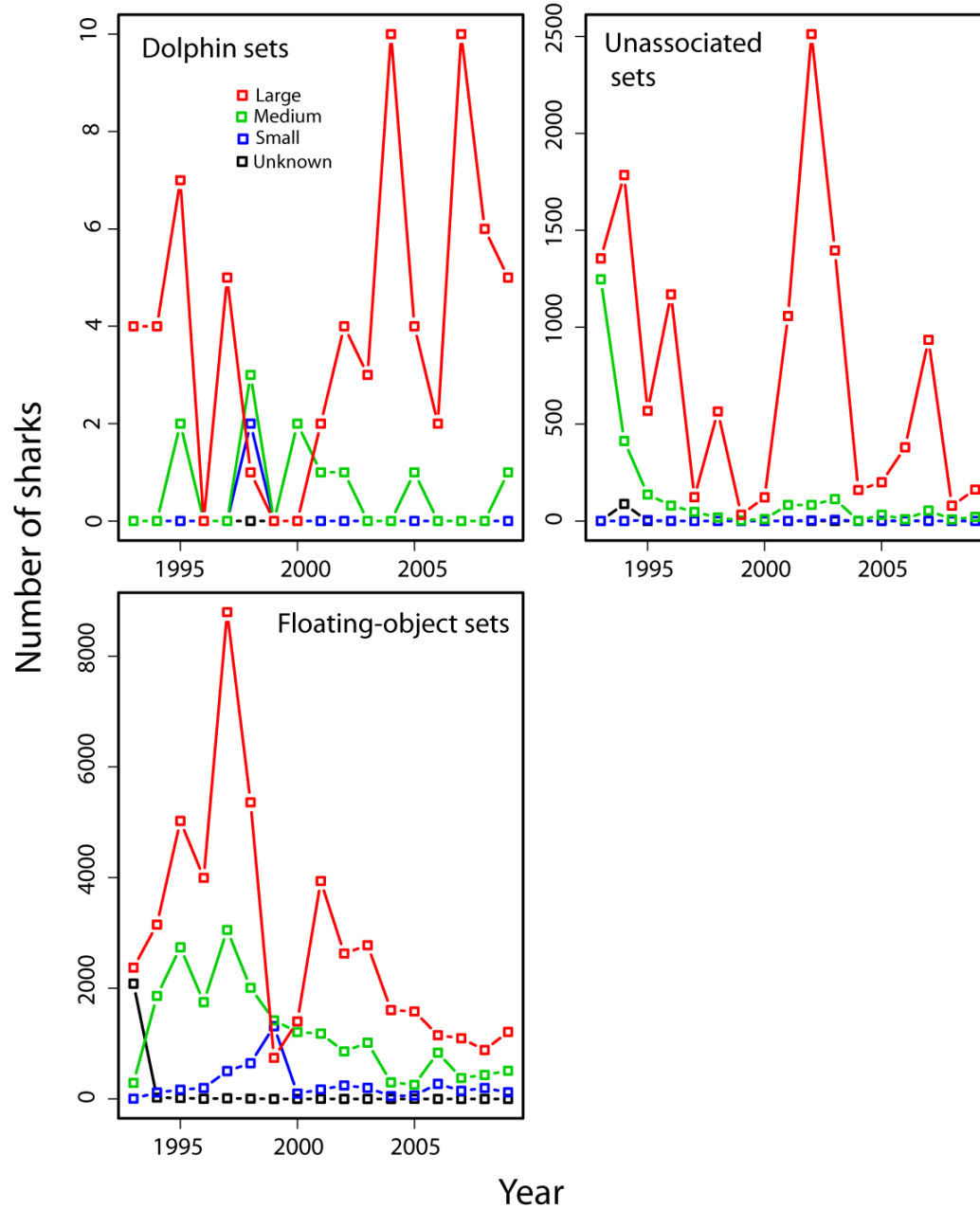
Total bycatch = bycatch-per-set (large vessels) x total sets (small vessels)



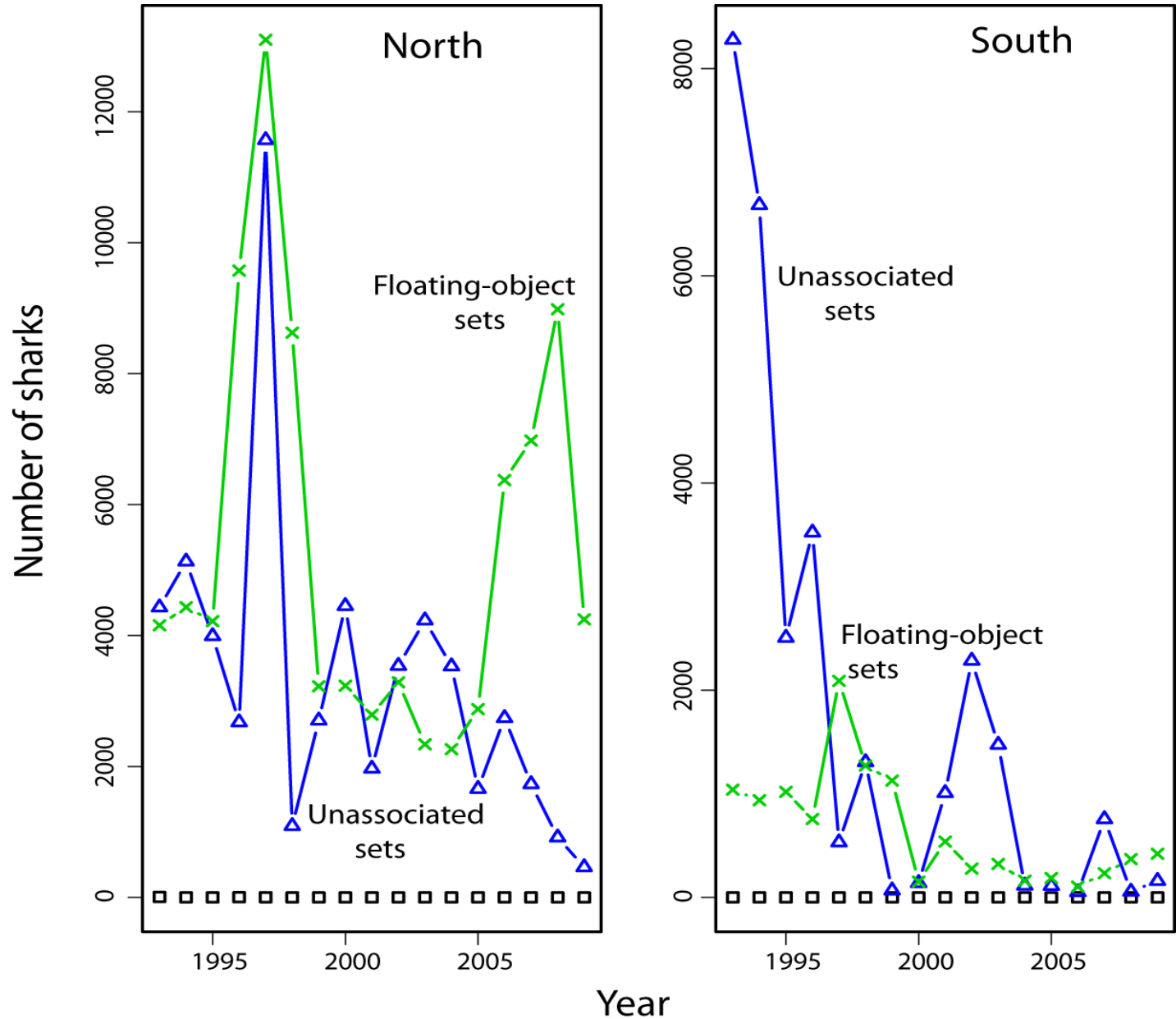
Total bycatch – north, large vessels



Total bycatch: south, large vessels



Total bycatch: small vessels, north and south



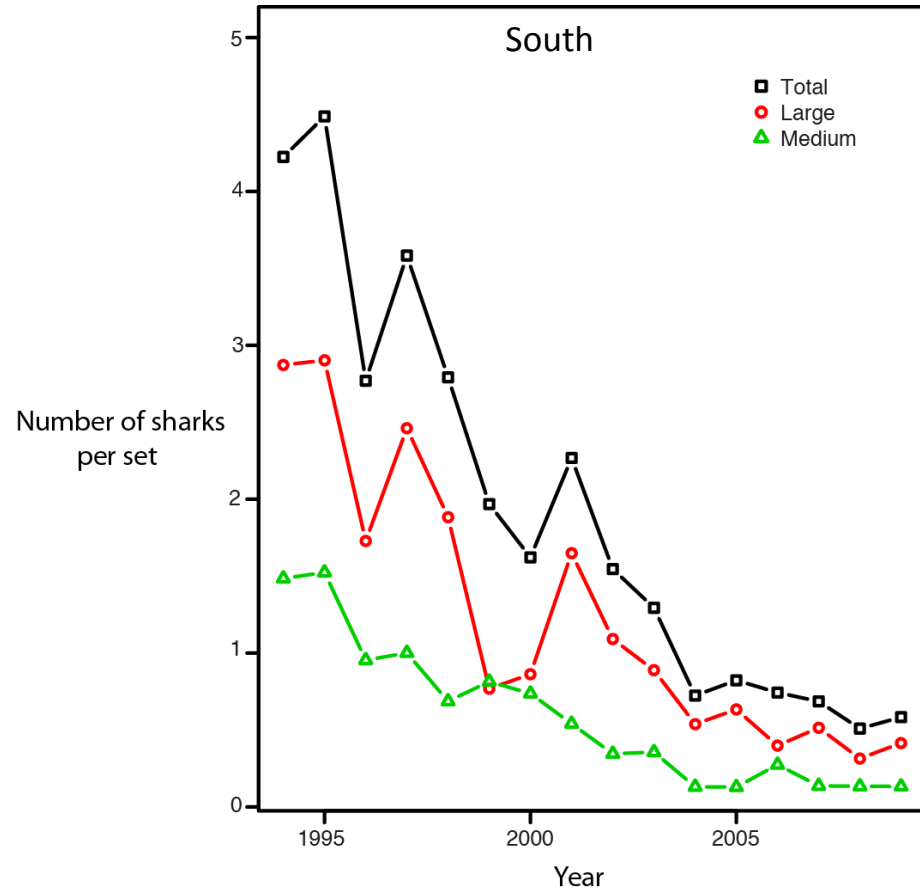
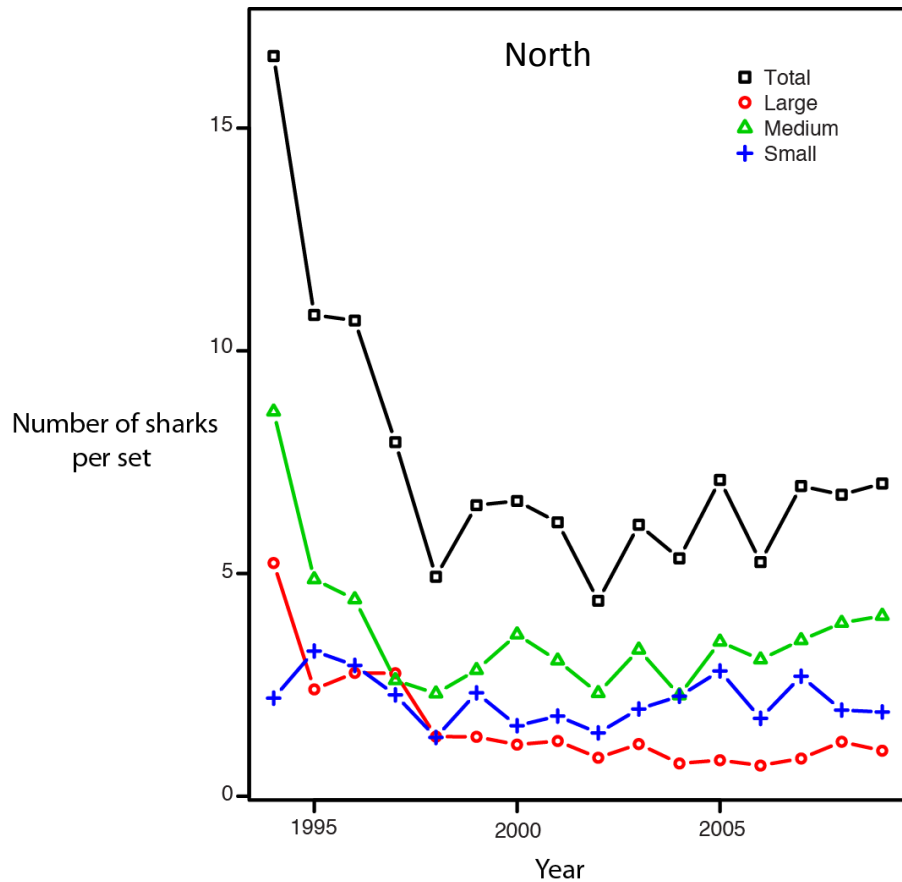
Standardized trends: floating-object sets

- Model used: zero-inflated negative binomial generalized additive model*.
- Models fitted separately to north and south for each size category (large vessels only).
- Data restricted to: 1994-2009, sets with tuna catch, “first” sets, and bycatch recorded in numbers. (47,413 sets)
- Response variable: number of sharks per set.
- Explanatory variables:
 - Smooth functions of latitude, longitude and calendar year;
 - Gear characteristics: net depth, object depth;
 - SST;
 - Proxies for size of object-associated community: tuna catch, bycatch of other species;
 - Proxies for local object density;
 - Year (categorical).

* Minami et al. 2007. Fisheries Research 84: 210-221.



Standardized trends in bycatch-per-set: floating-object sets

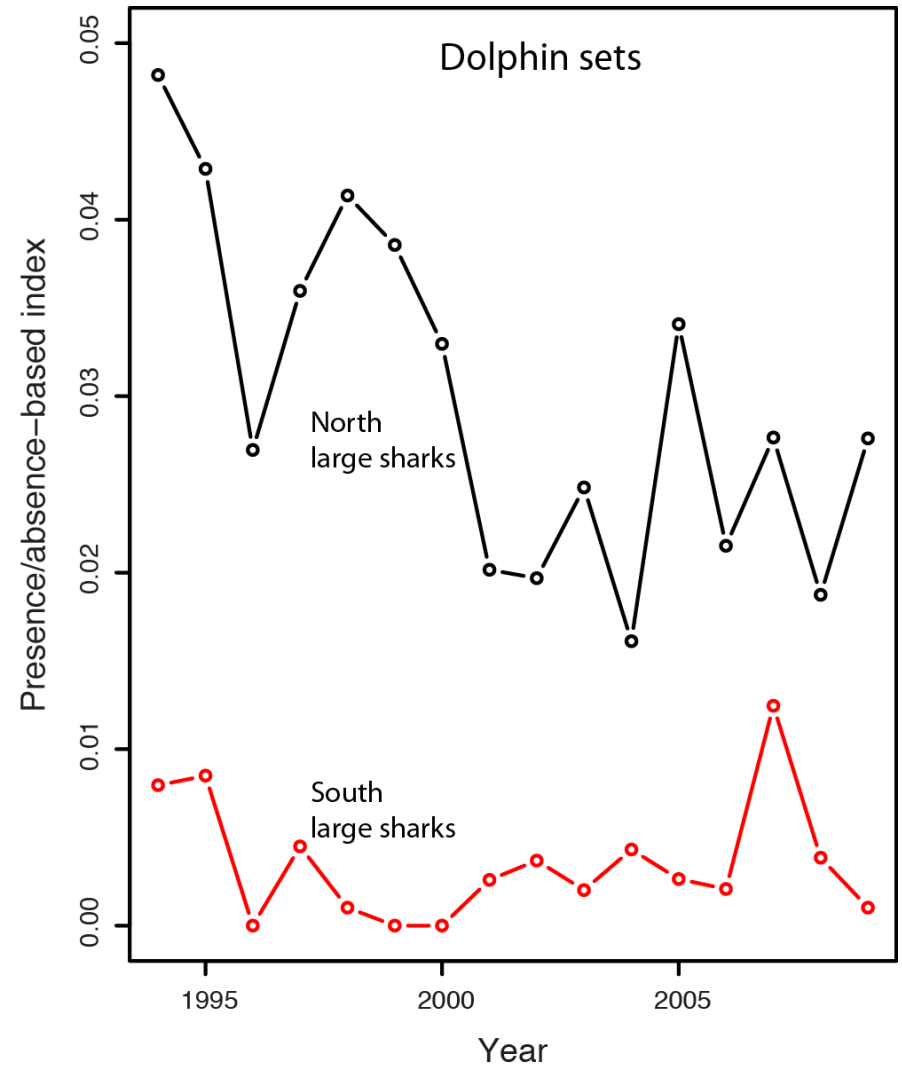
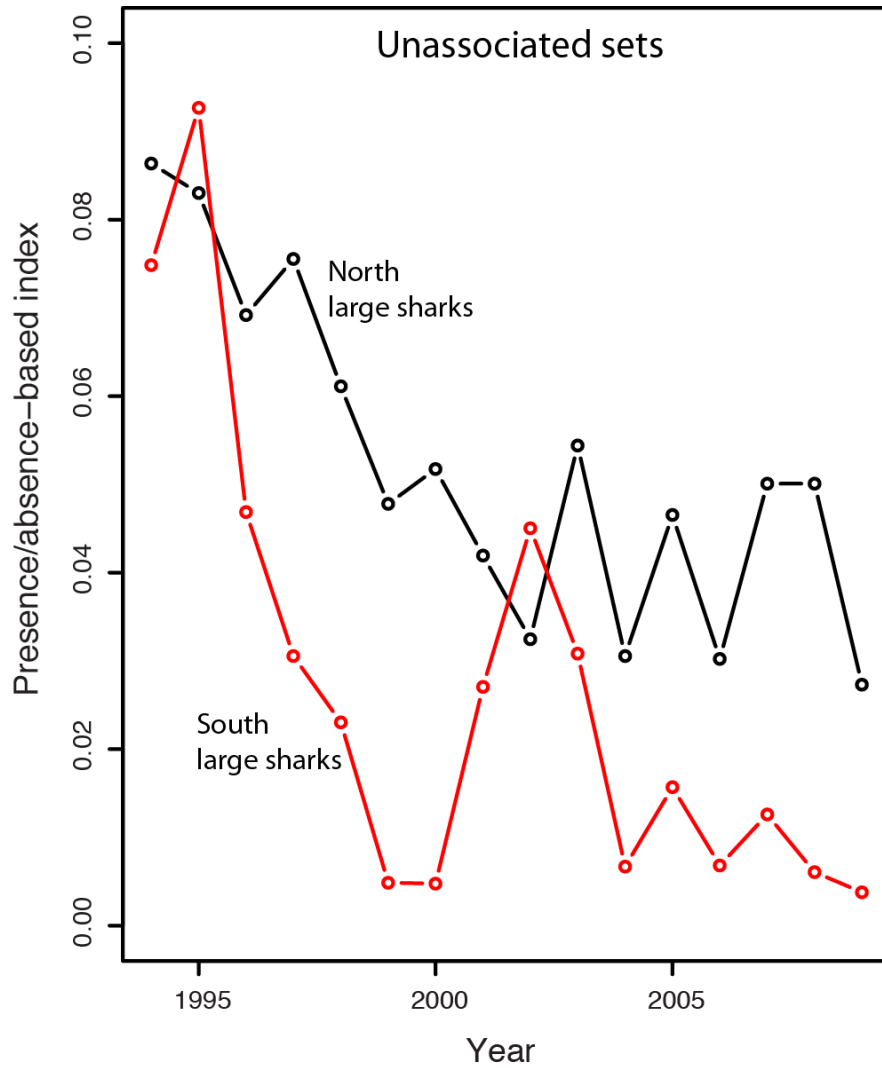


Standardized trends: unassociated and dolphin sets

- Model used: logistic generalized additive regression model.
- Models fitted separately to north and south for large sharks and all sharks (large vessels only).
- Data restricted to: 1994-2009 and bycatch recorded in numbers. (36,506 unassociated sets; 90,099 dolphin sets)
- Response variable: presence/absence (presence = one or more sharks caught).
- Explanatory variables:
 - Smooth functions of latitude, longitude and calendar year;
 - Operational and gear variables (e.g., time to encircle the tuna, net depth);
 - SST;
 - tuna catch;
 - Year (categorical).



Presence-absence index for large sharks



Size composition

Estimated only for large vessels.

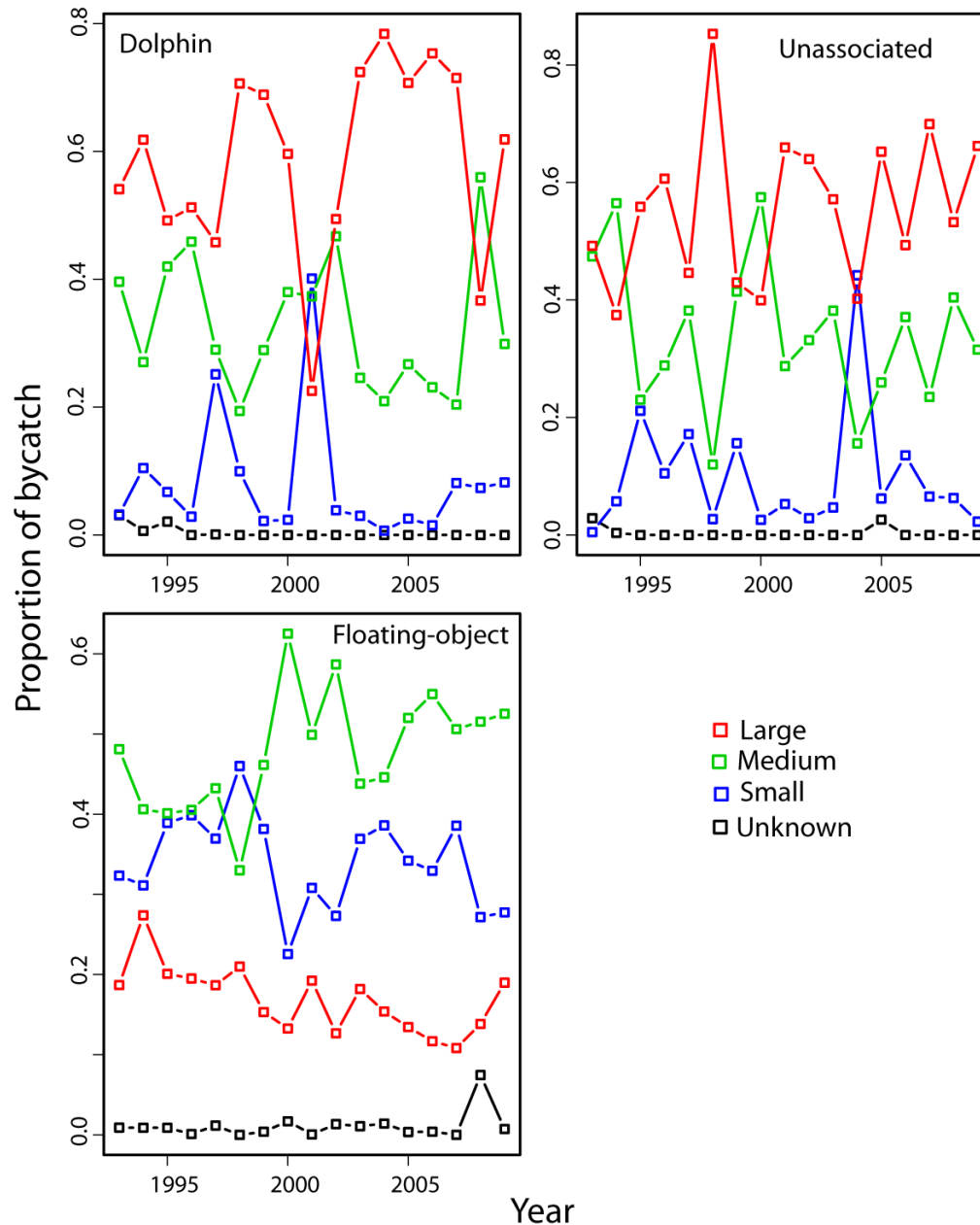
Estimated separately by purse-seine set type, north and south.

Proportion of each size category

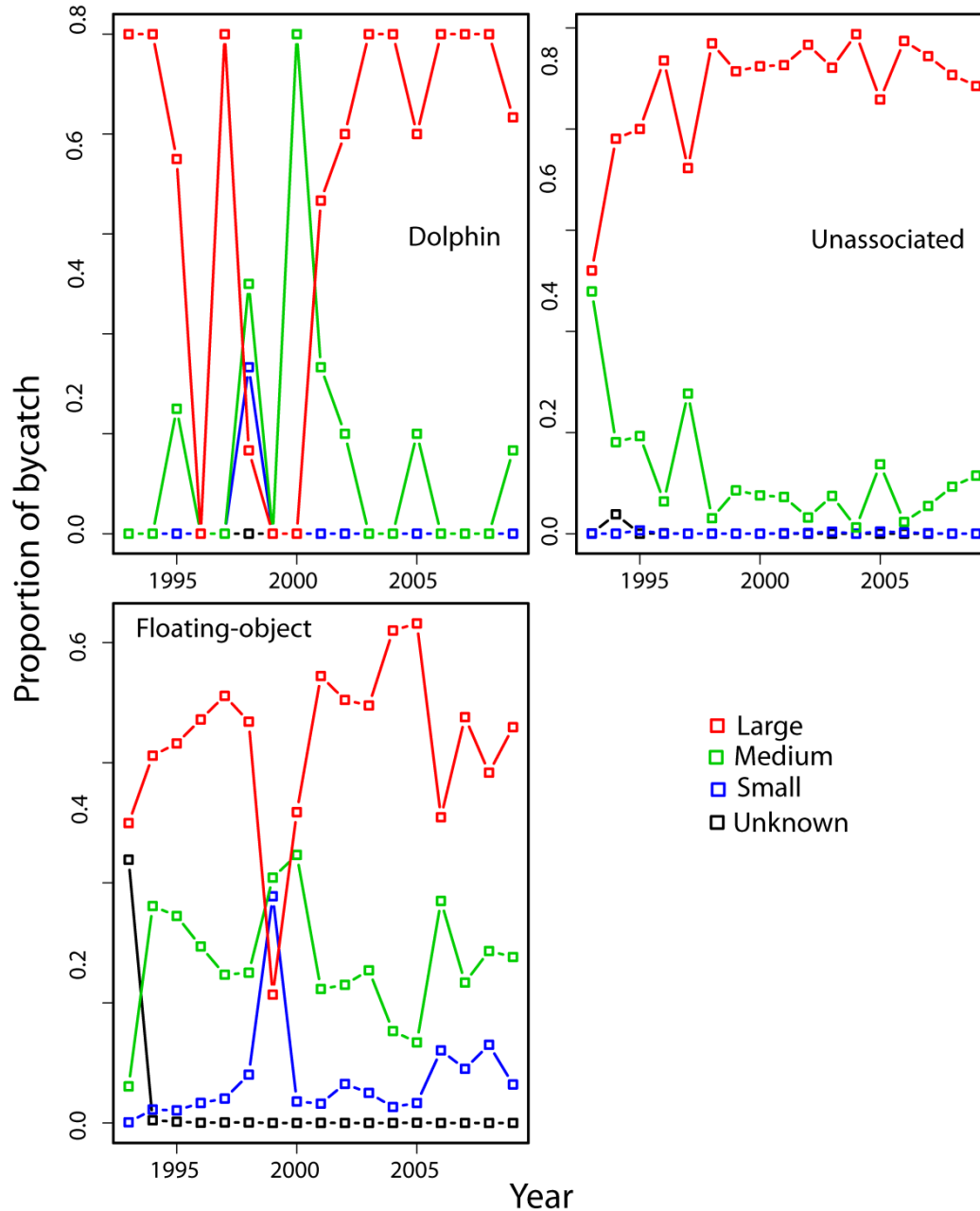
= number of sharks in size category / total number of sharks



Size composition, north (large vessels)



Size composition, south (large vessels)

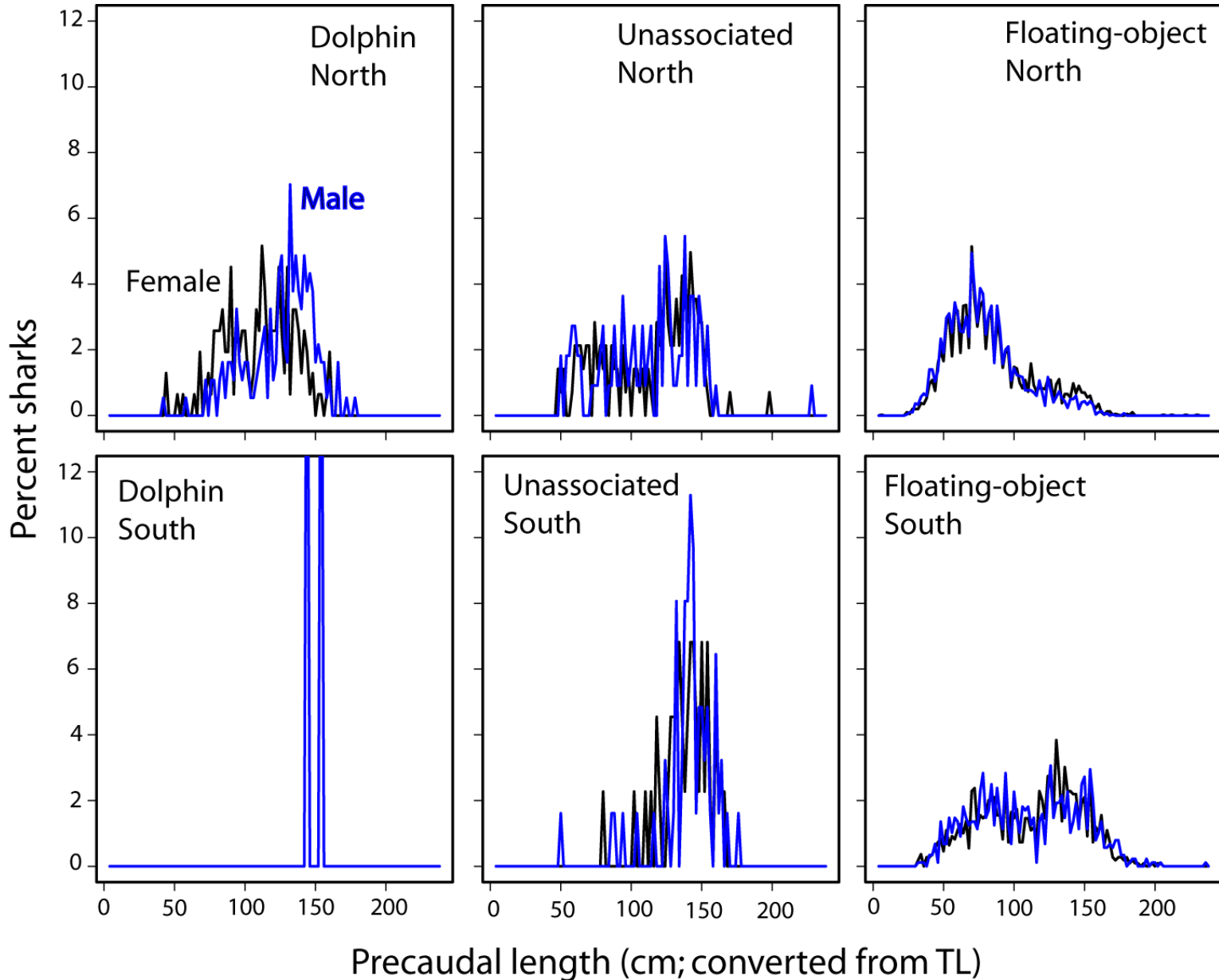


Length-frequency data

- Detailed length and sex data available beginning in 2005.
- Total length is measured in cm.
- Length/sex data not available for all animals in bycatch.
- Total length converted to precaudal length (SRP Ecuador).



Length-frequency: example for 2006



Summary of available purse-seine information

- Effort: 1993-2009
- Total bycatch: 1993-2009
- Standardized trends (large vessels): 1994-2009
- Size composition (size categories) (large vessels): 1993-2009
- Length-frequency (by M/F) (large vessels): 2005-2009

