A preliminary analysis of the relationship between the number of FAD deployments and the number of FAD sets for the EPO purse-seine fishery

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Background

- Several management options proposed for the EPO purse-seine fishery on floating objects have included limits on the numbers of FADs and/or on the number of FAD sets (IATTC-90 PROP A-3 COL; IATTC-90-INF-B ADDENDUM 1).

- FAD limits have been adopted by IOTC (IOTC Resolution 16-01) and ICCAT (ICCAT Recommendation 16-01).

- However, scientific studies addressing the appropriateness of these limits generally have not been done due to a lack of information on the current numbers of FADs deployed, as well as on knowledge of the at-sea FAD dynamics.

- This lack of information is problematic because FAD limits may influence vessel fishing strategies.

- Quantitative analyses, which may help inform discussion, can be undertaken for the EPO because of the detailed data collected by AIDCP observers aboard Class-6 purse-seine vessels.

Outline of presentation

- Preliminary results of several analyses conducted using AIDCP observer data for 2012-2015 will be presented:
  - Exploratory analysis of vessel fishing strategies using cluster analysis methods;
  - Analysis of the relationship between FAD deployments and number of floating-object and FAD sets using mixed-effects models.

- Funding for this work was provided by the International Seafood Sustainability Foundation.

Fishing strategies

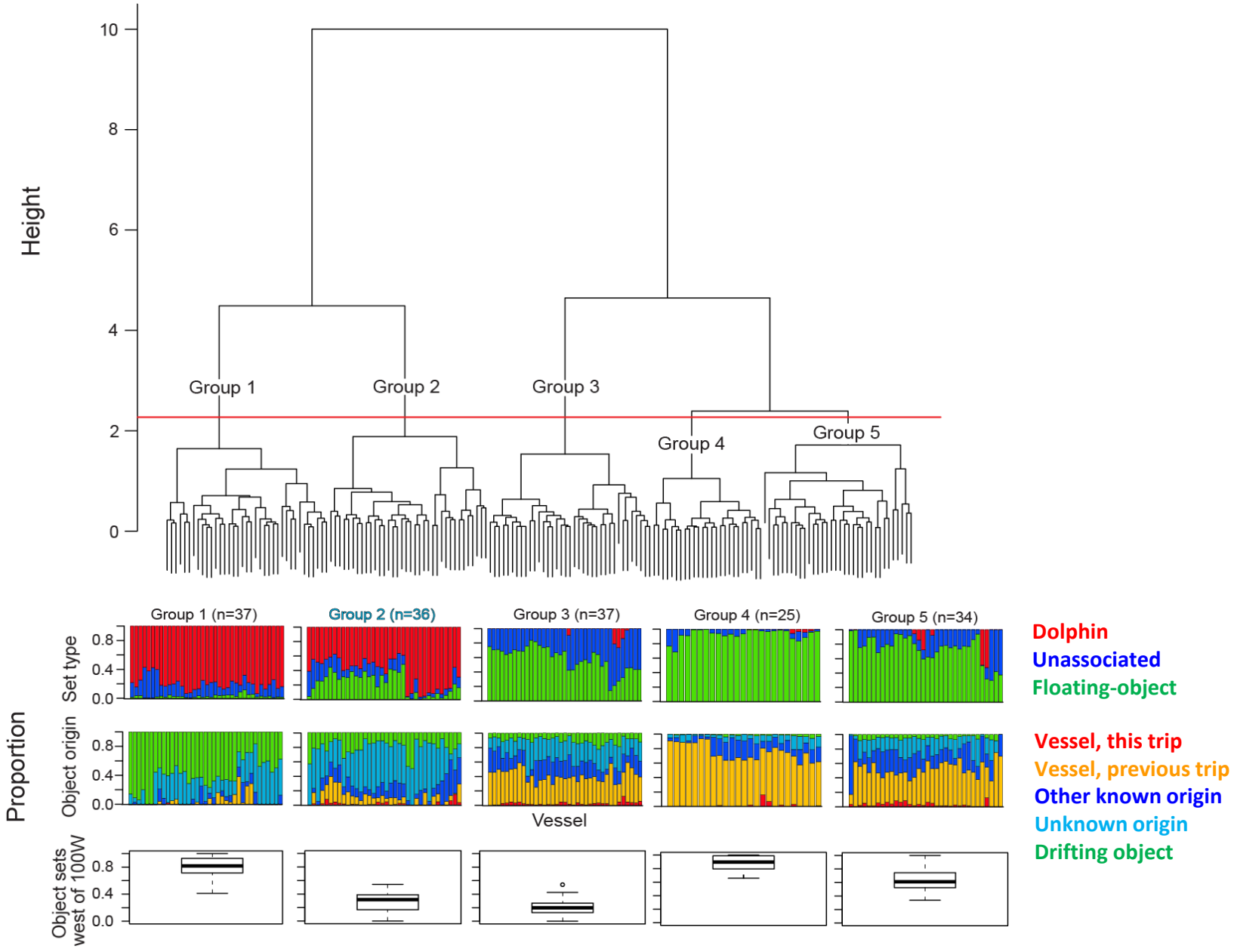
Data

- Collected by AIDCP observers aboard Class-6 purse-seine vessels.
- EPO for 2012-2015.
- Vessels making at least five floating-object sets.

Methods

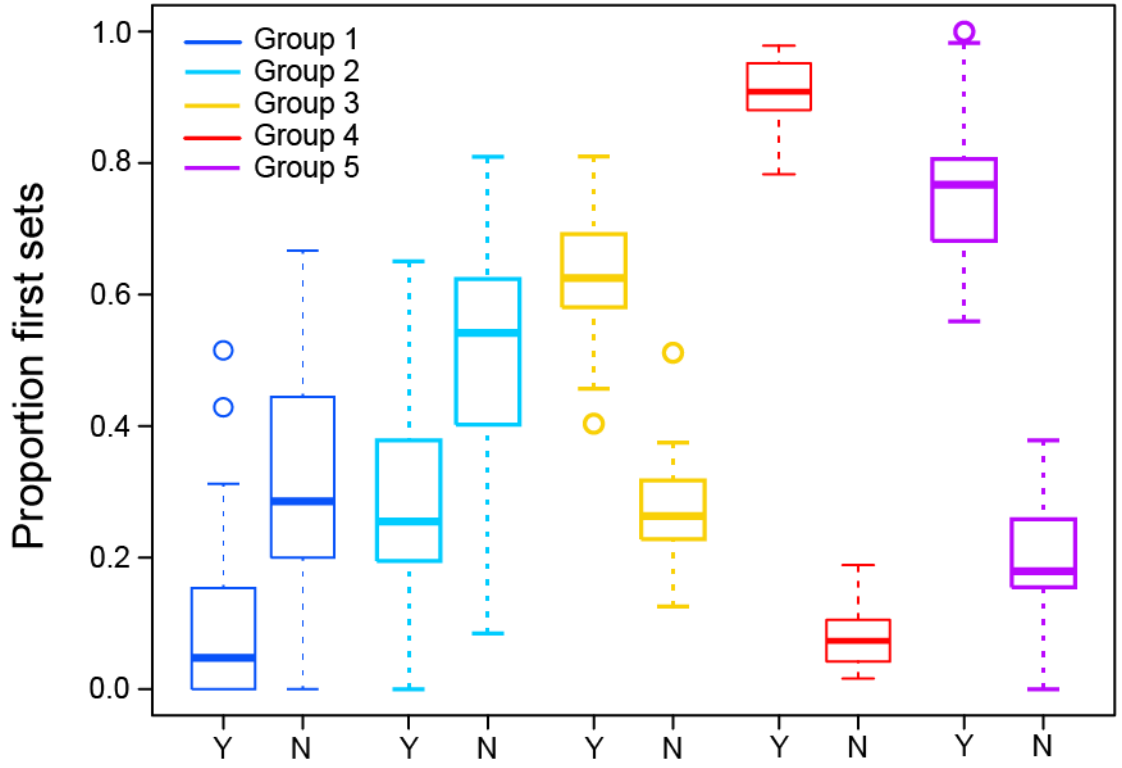
- Agglomerative hierarchical clustering (Euclidean distance, Ward's method).
- Variables used:
  - Proportion of sets by set type (floating-object, unassociated, dolphin).
  - Proportion of floating-object sets by object origin (first set on object):
    - FAD origins:
      - deployed by the vessel, this trip or previous trip;
      - other known origin;
      - unknown origin;
    - drifting object (*i.e.*, presumably a natural floating object).
  - Proportion of floating-object sets made west of 100°W.
- Analyses done in R with *hclust*, and with *agnes* (cluster package).

Fishing strategies



Fishing strategies

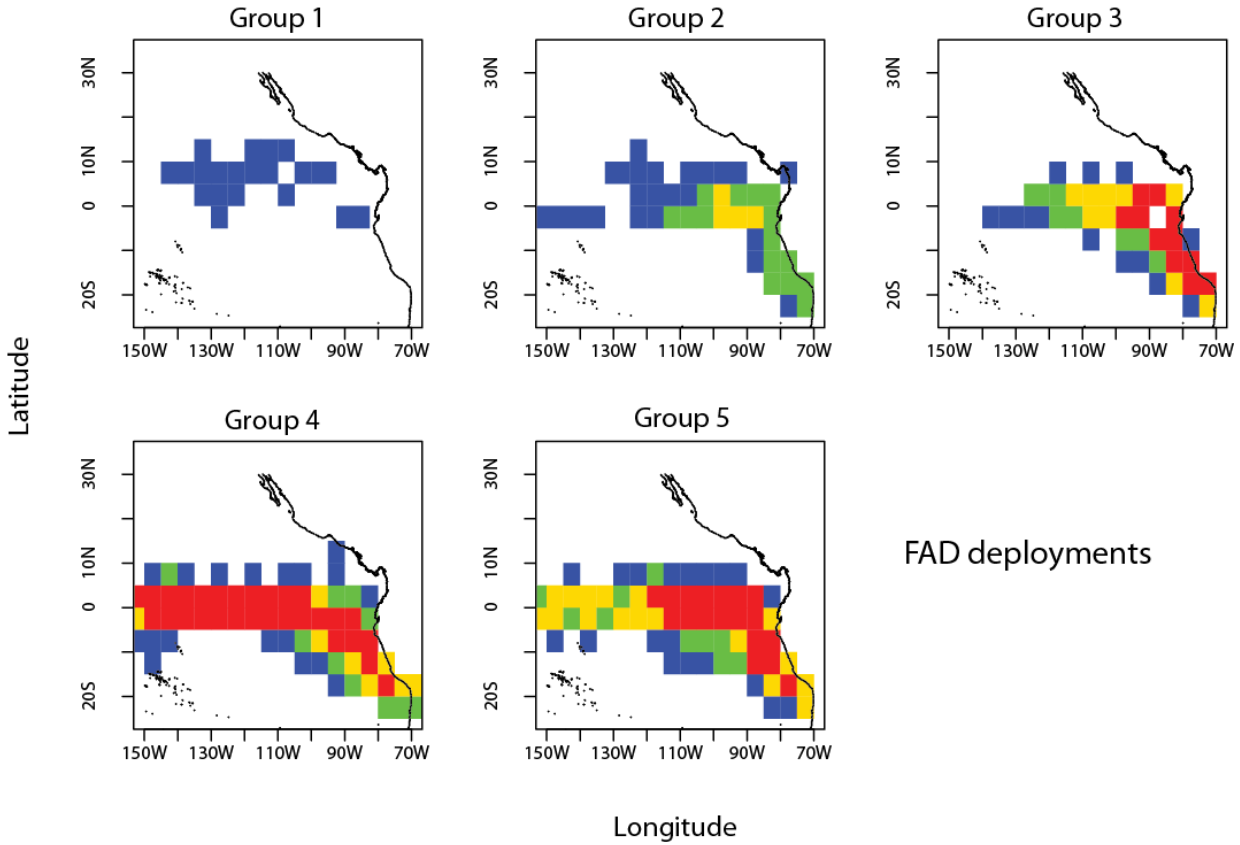
Proportion of sets, by cluster group, according to FAD origin



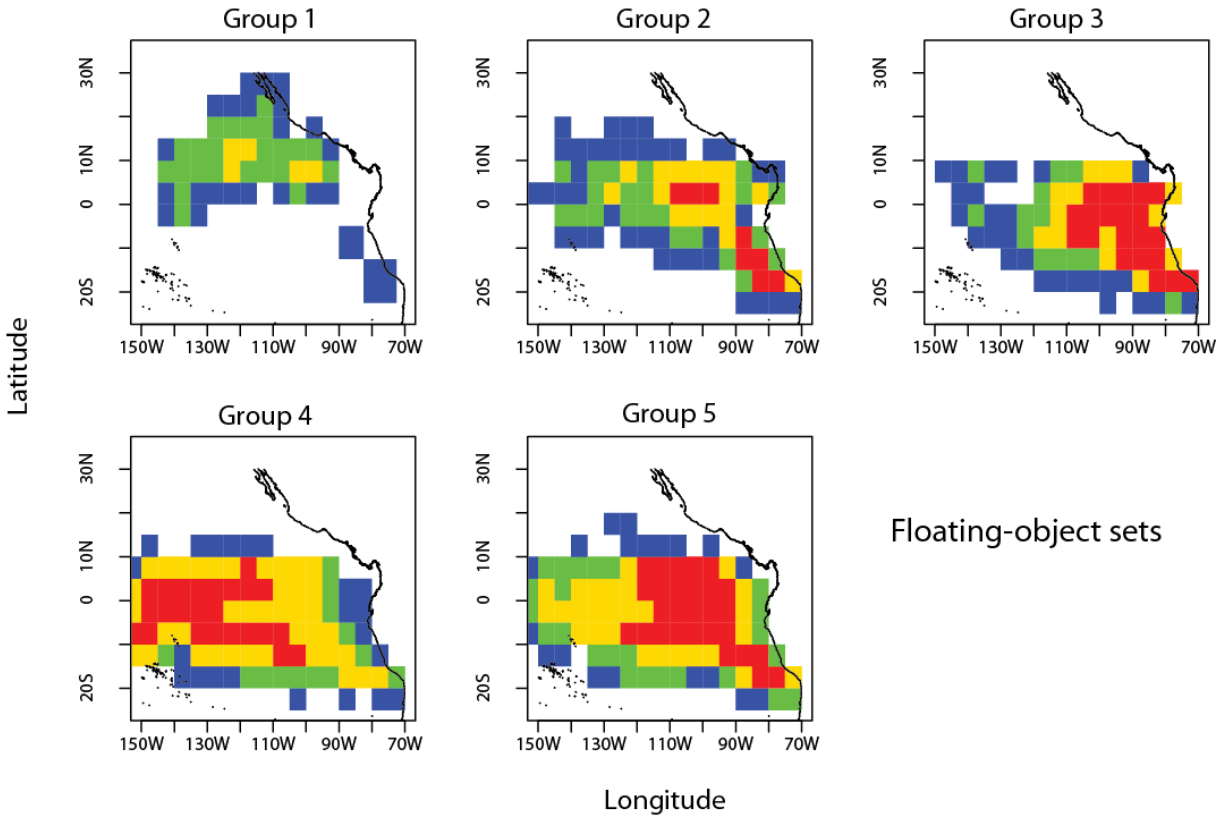
"Y": FADs deployed by the vessel and other FADs of known origin
"N": FADs of unknown origin

Fishing strategies

FAD deployment and floating-object set locations, by cluster group



FAD deployments



Floating-object sets

Number of deployments

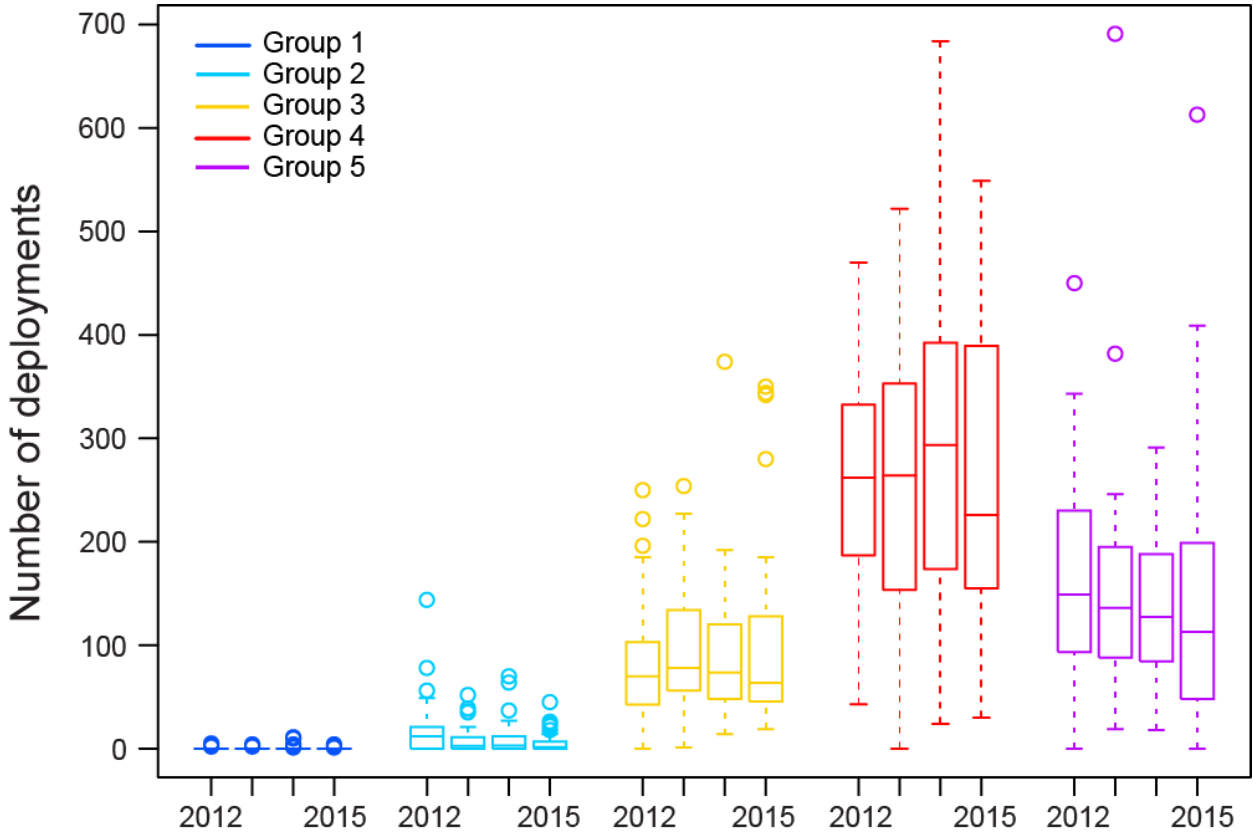
- Blue: 1-20
- Green: 21-90
- Gold: 91-320
- Red: > 320

Number of sets

- Blue: 1-10
- Green: 11-40
- Gold: 41-140
- Red: > 140

Fishing strategies

Number of FAD deployments* per vessel, by cluster group and year



*Includes deployments to 180°W

Fishing strategies

Preliminary results

- Strong clustering of vessels was identified.

- Primary clusters: vessels making a larger proportion of dolphin sets *versus* vessels making a larger proportion of floating-object and unassociated sets.

- Factors differentiating secondary clusters
  - The two groups of dolphin-set vessels:
    - Proportion of sets on tunas associated with drifting objects *versus* with FADs of unknown origin;
    - Areas of FAD deployment and floating-object set activity.

  - The three groups of floating-object vessels:
    - Proportion of unassociated sets;
    - Proportion of sets on their own FADs *versus* on FADs of unknown origin;
    - Areas of FAD deployment and floating-object set activity;
    - Number of FAD deployments.

FAD deployments *versus* sets

Data

- Entire trips with departure year in 2012 to 2015

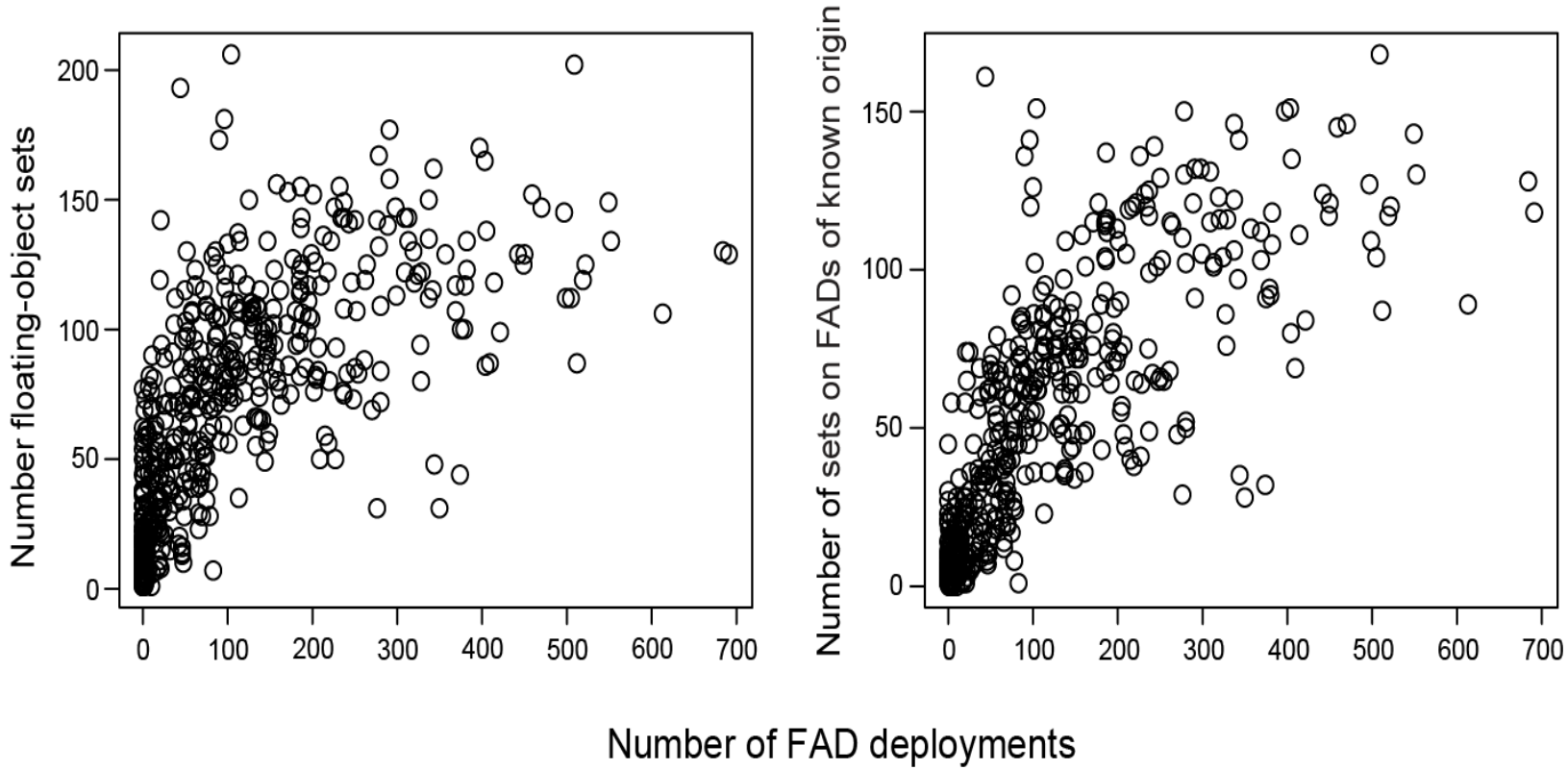
- For each vessel, annual tallies (by departure year) were computed:
  - Number of FAD deployments;
  - Number of sets on floating-objects;
  - Number of sets on FADs of known origin (*i.e.*, the vessels own FADs and other FADs of known origin).

- All sets, including repeat sets on the same object and sets made west of the EPO (to 180°W), were included in this analysis.

- All deployments from the coast to 180°W were included in the analysis.

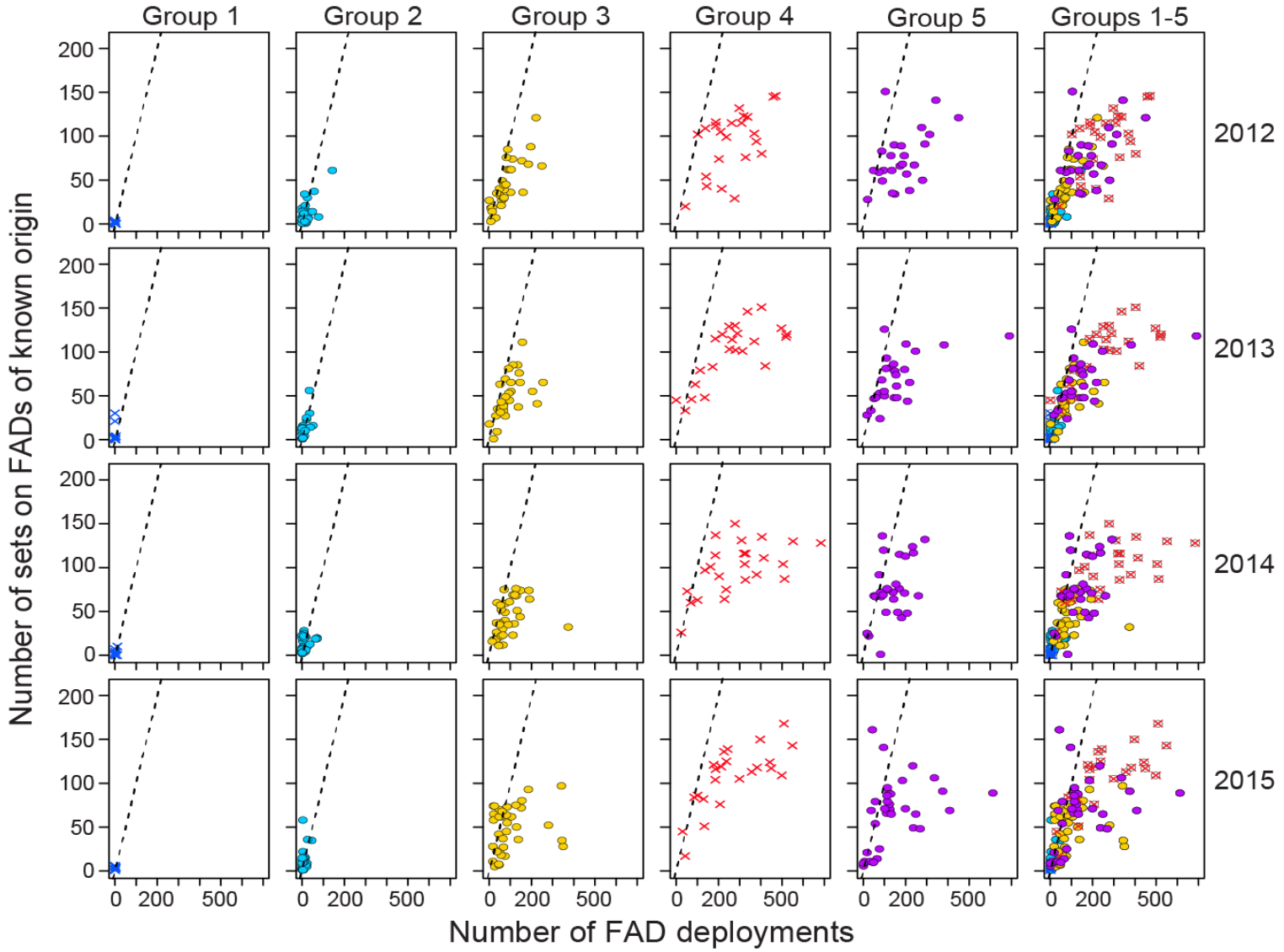
FAD deployments *versus* sets

Relationship without regard for cluster group



FAD deployments *versus* sets

FAD deployments
Versus
FADs of known origin



FAD deployments *versus* sets

Modeling the relationship

- Assuming that the relationship between deployments and sets can have an asymptote, consider a model of the following form:

$$number\ of\ sets = \alpha * (number\ of\ deployments)^{\beta}$$

- The following linearized model was fitted to data for each floating-object vessel group:

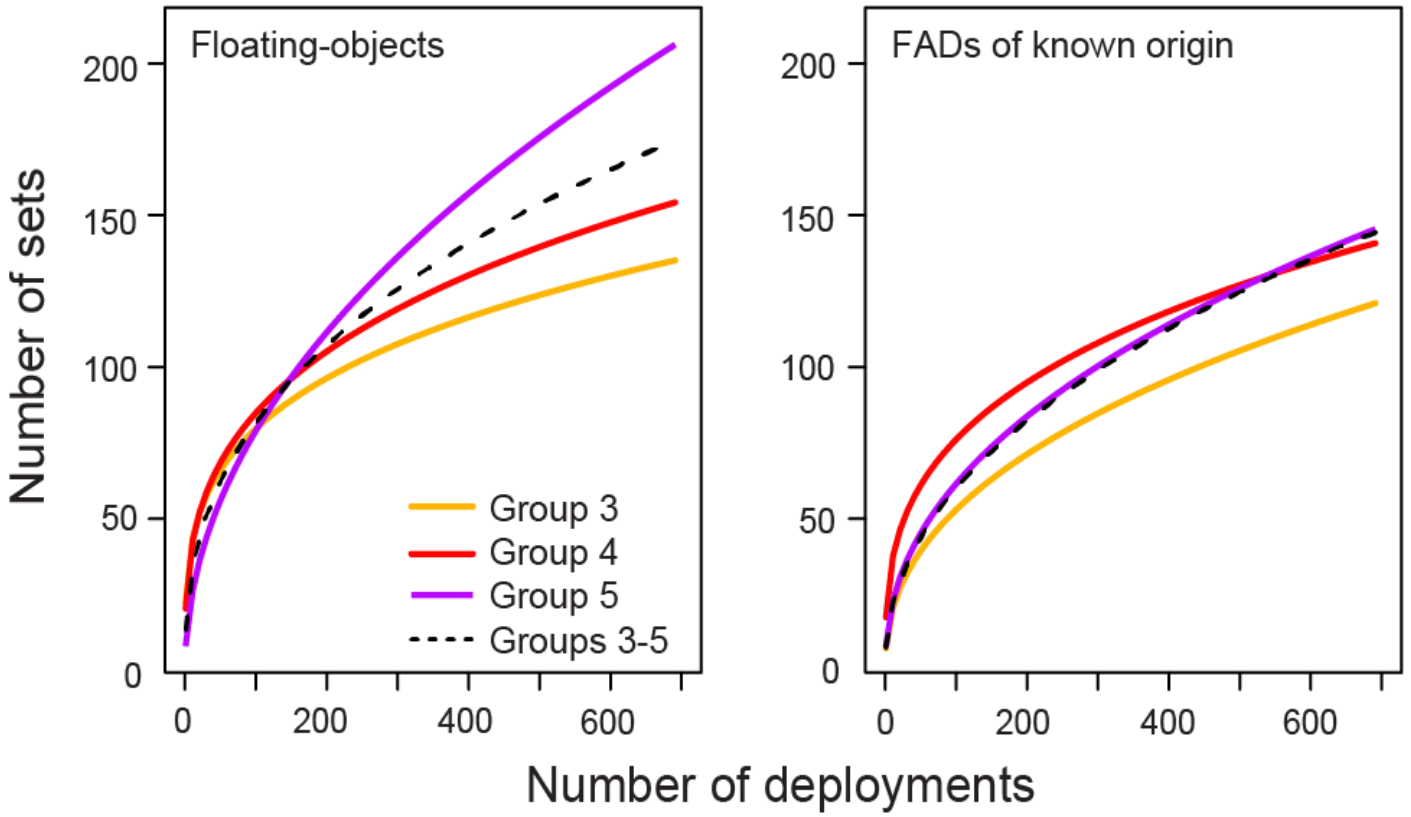
$$\log(number\ of\ sets_{ij}) = \tilde{\alpha} + \tilde{\gamma}_j + \beta * log(number\ of\ deployments_{ij} + 1)$$

  where $\tilde{\gamma}_j$ is a vessel effect (random effect).

- Models with year as a main effect, and with an interaction between β and year, also were fitted.
- Based on AIC and BIC, ignoring year resulted in the “best” model.
- Examples of predicted curves were generated for the simplest model, using the full range of numbers of deployments and assuming a vessel effect of 0 (on the log scale).

FAD deployments *versus* sets

Examples of predicted curves from the model without year



FAD deployments *versus* sets

Preliminary results

- The overall relationship between the number of FAD deployments and number of sets is nonlinear and appears to asymptote beyond several hundred FAD deployments annually.
- The predicted curves for sets on FADs of known origin suggest that the rate of return on FAD deployments could be less when fishing closer to the coast than when fishing further offshore.
- Including sets on FADs of unknown origin/drifting objects appears to have the greatest effect on the relationship for the two floating-object set groups fishing closer to the coast and making proportionally more unassociated sets.

Conclusions

- The groups of vessels, based on their different fishing activities, were well defined.
- Fishing strategies for floating-object-set vessels differed depending on the area of fishing activity:
  - Vessels fishing offshore tended to make sets primarily on FADs of known origin, had lower proportions of unassociated sets, and made a greater number of FAD deployments;
  - Vessels fishing inshore tended to make proportionally more sets on FADs of unknown origin/drifting objects, had higher proportions of unassociated sets, and made a lesser number of FAD deployments.
- The overall relationship between the number of FAD deployments and number of sets is nonlinear and appears to asymptote beyond several hundred FAD deployments annually.
- The rate of increase of sets on FADs of know origin with FAD deployments appears to be less when fishing closer to the coast than when fishing further offshore.
- The complexity of FAD fishing strategies is due in part to the fact that the ownership of a FAD can change during its lifetime, so that the number of deployments for a given vessel may not correspond with the monitored, active FADs at sea.

Future work

- Analyses of the relationship between the number of FAD deployments and catch-per-set, as another means of evaluating any benefits from increased numbers of deployments, are in progress.
- Analyses of vessel fishing strategies in earlier years are also in progress to determine if/how strategies have changed over time.
- Alternative models for numbers FAD deployments *versus* numbers of sets will be explored and confidence intervals for predicted curves will be estimated.