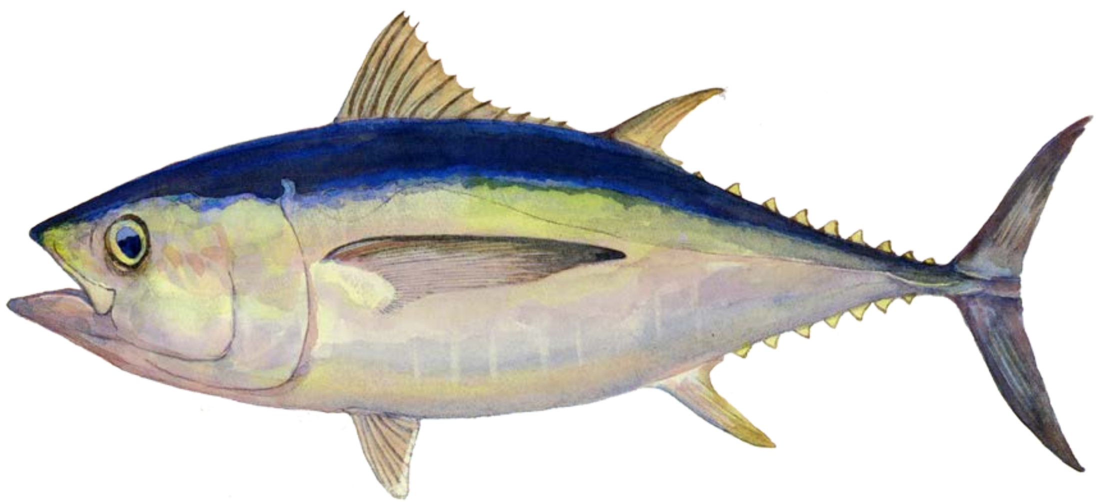
Preliminary evaluation of several options for reducing bigeye tuna catches

SAC-07-07e



Outline of presentation

- Identifying areas of high bigeye tuna catch by purse-seine vessels
  - Define high-catch areas
  - Preliminary evaluation of potential spatial closures

- Updating a study of effects of environmental factors and gear characteristics on probability of bigeye tuna catch by purse-seine vessels
  - Importance of environmental and gear variables for predicting the presence/absence of bigeye
  - An illustration of weekly forecasting of the spatial distribution of the probability of bigeye catches

Identifying areas of high bigeye catch

- Data: floating-object sets of Class-6 purse-seine vessels, 2001-2015.

- Generalized additive model (GAM) for bigeye catch (= retained + discards)
  - Used a delta-Gamma model because (~50% of sets had no bigeye catch).
  - Logistic regression model for presence/absence of bigeye catch:

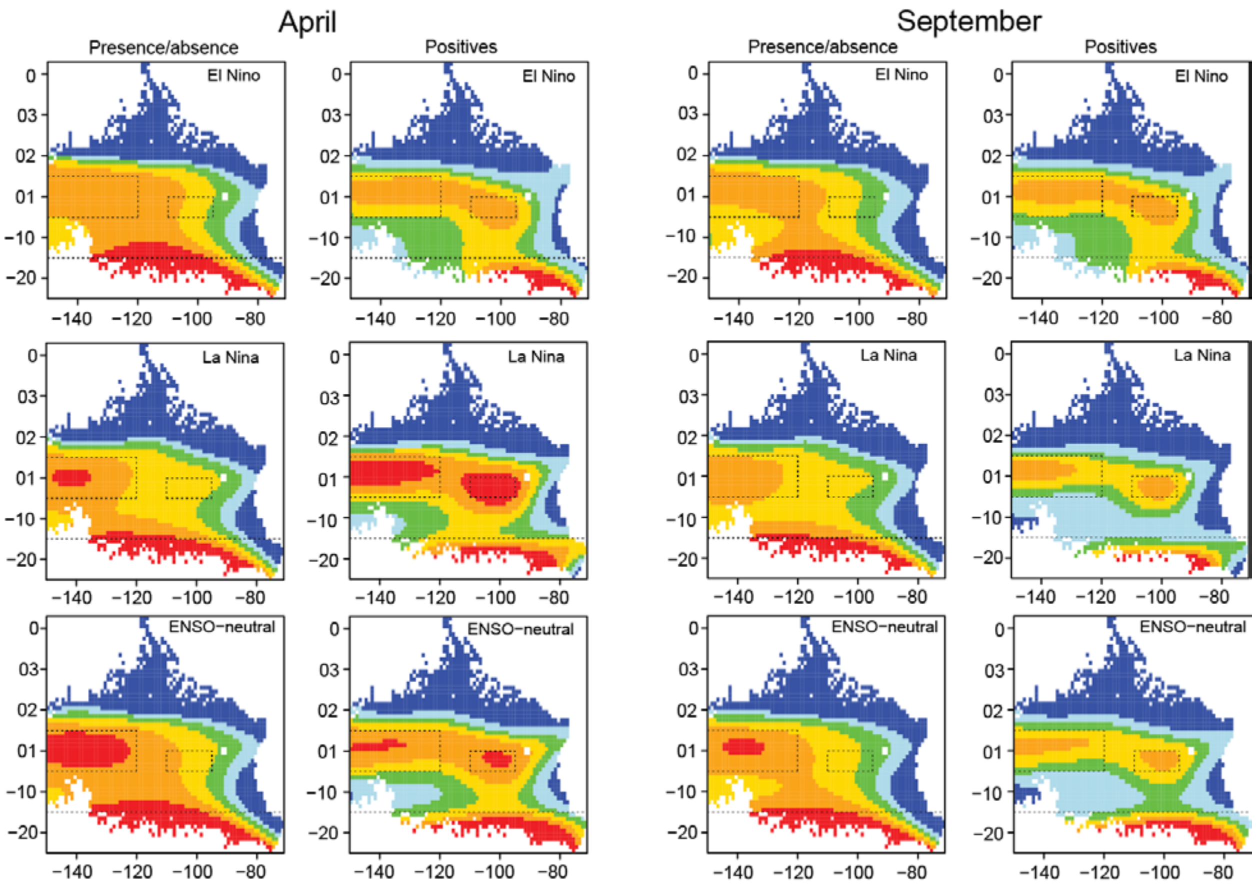
    logit(p) = te(latitude, longitude, by ENSO category)+s(month, by ENSO category)

  - Gamma with log link for catch-per-set ("positives"; CPS):

    log(CPS) = te(latitude, longitude, by ENSO category)+s(month, by ENSO category)

    ENSO categories: El Niño, La Niña, ENSO-neutral

Identifying areas of high bigeye catch



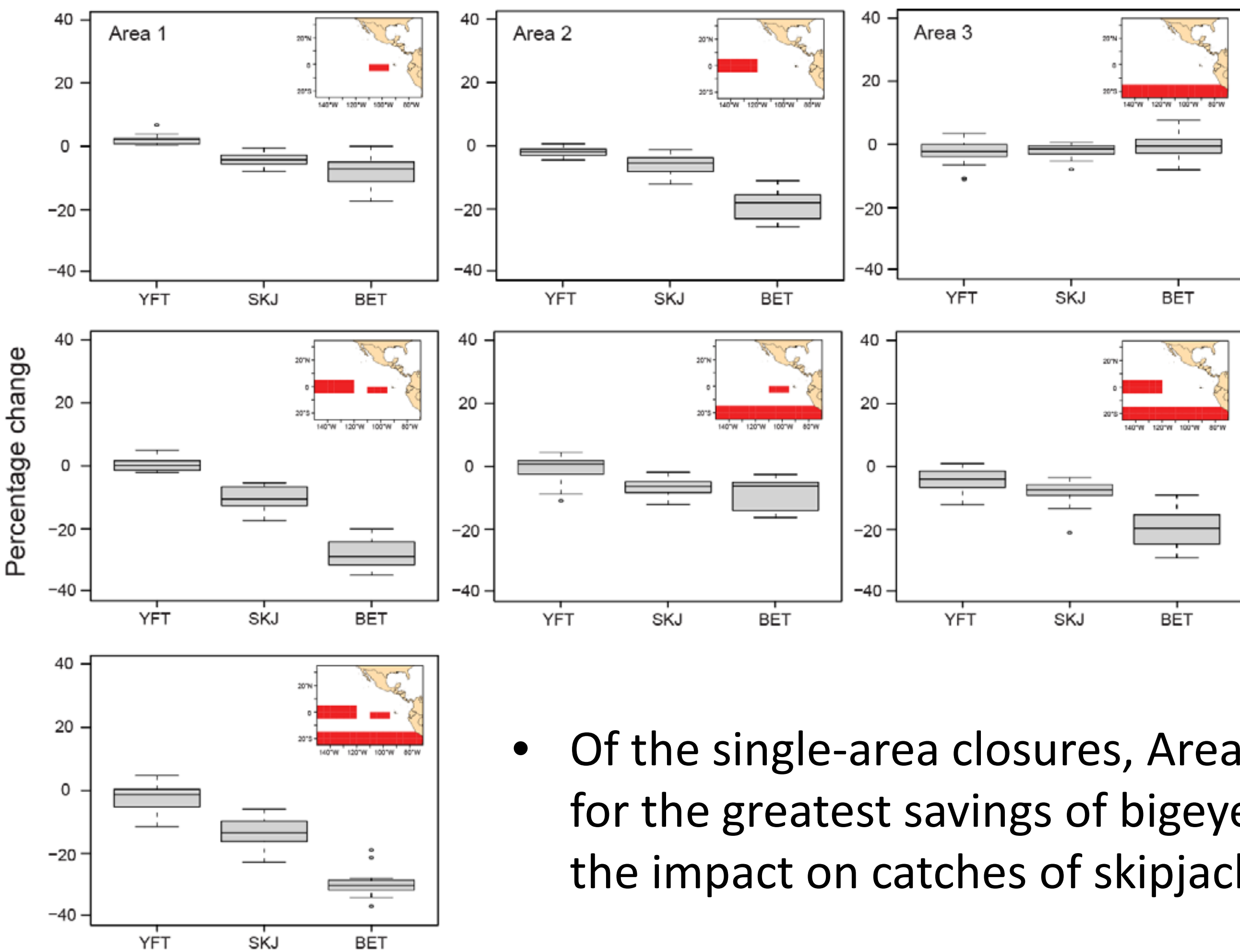
Based on spatial predictions from the GAMs, three high-catch areas were defined:

1) 5°S to the equator, 95°W-110°W (overlaps with the *corralito*);
2) 5°S-5°N, and 120°W-150°W; and,
3) south of 15°S.

Simulation of potential purse-seine spatial closures

- Evaluated, by year, 2001-2015:
  - Seven combinations of the three areas (1; 2; 3; 1 and 2; 1 and 3; 2 and 3; 1, 2 and 3);
  - Year-long closure;
  - Floating-object and unassociated sets (dolphin sets excluded).
- Data: IATTC Catch-and-Effort data base for Class 1-6 purse-seine vessels; retained catch.
- Simulation steps:
  - Reallocate sets inside the closed area(s) outside, based on effort composition of the outside area, by 5° square;
  - Estimate catch amounts (bigeye, skipjack, yellowfin) for reallocated sets based on catch-per-set in each 5° square;
  - Estimate fleet catch for a given scenario, by year, as the sum of actual catch outside, plus estimated catch from the reallocated sets;
  - Annual effect of each scenario is the difference between the actual fleet catch and the estimated fleet catch.

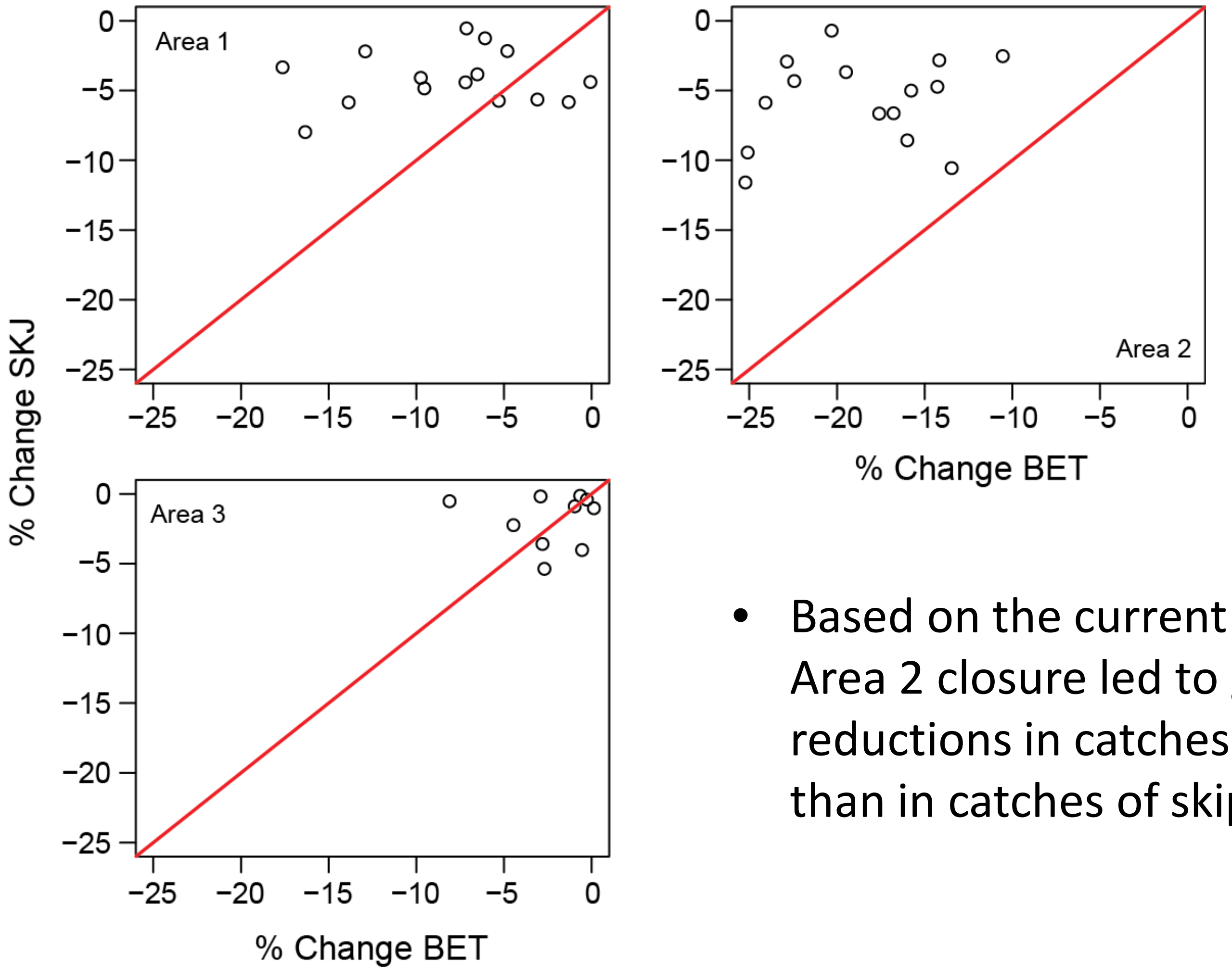
Simulation of potential purse-seine spatial closures



- Of the single-area closures, Area 2 may have the potential for the greatest savings of bigeye tuna catch while limiting the impact on catches of skipjack tuna.

- Combinations of closed areas, especially those that included Area 2, resulted in greater reductions in bigeye catch, but also greater reductions in the catch of skipjack.

Simulation of potential purse-seine spatial closures



- Based on the current simulation, the Area 2 closure led to greater reductions in catches of bigeye tuna than in catches of skipjack tuna.

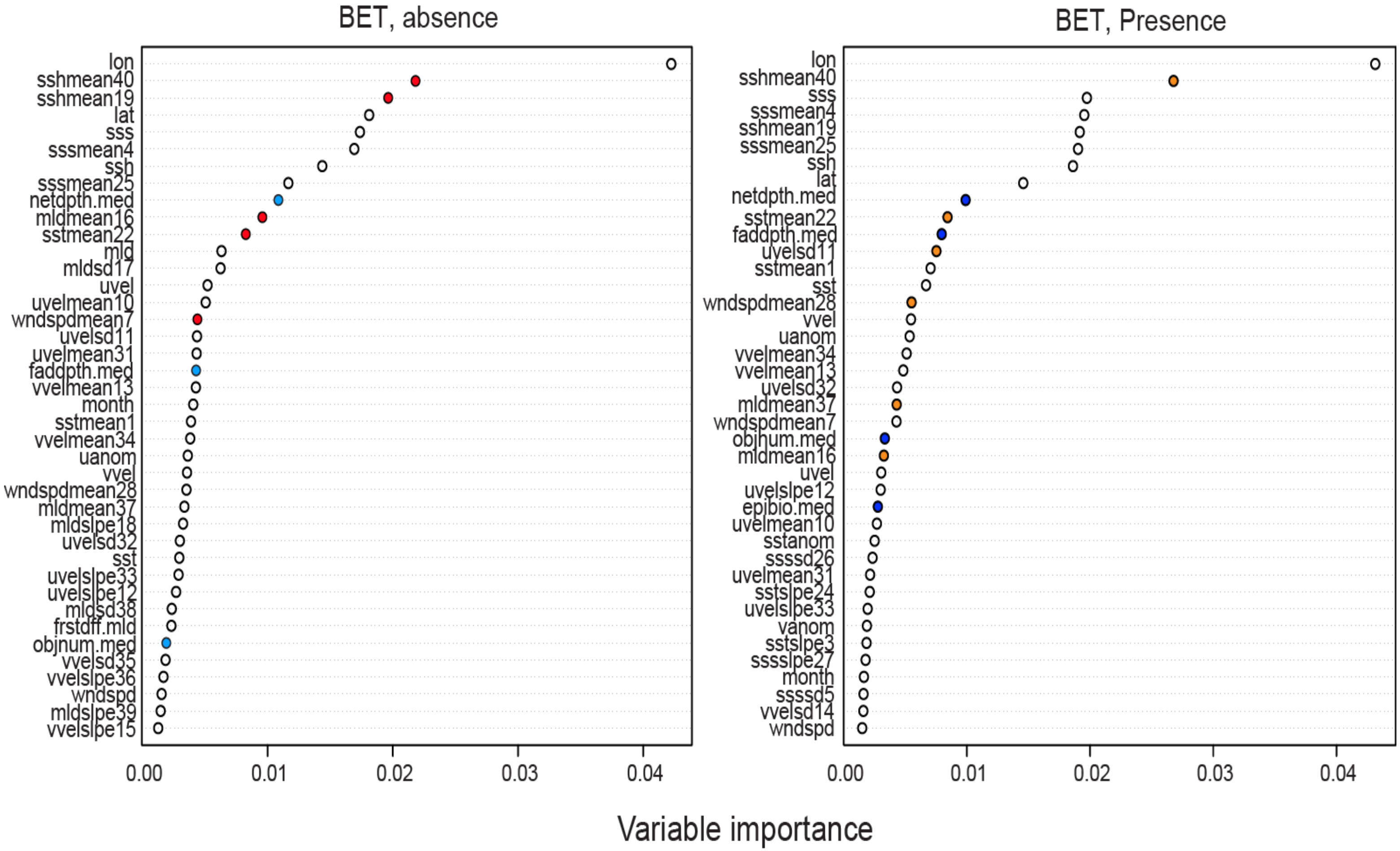
Summary and Future Work

- Preliminary results suggest that a spatial closure of equatorial waters in the western EPO may result in a greater reduction of bigeye catches than in loss of skipjack catch.
- More realistic effort reallocation schemes could be considered, e.g., by vessel, according to each vessel's fishing habits.
- Closure spatial boundaries and time periods would ideally be selected based on an optimization scheme that maximizes the reduction in bigeye while minimizing the loss of skipjack.

Environmental and gear effects on the probability of catching bigeye

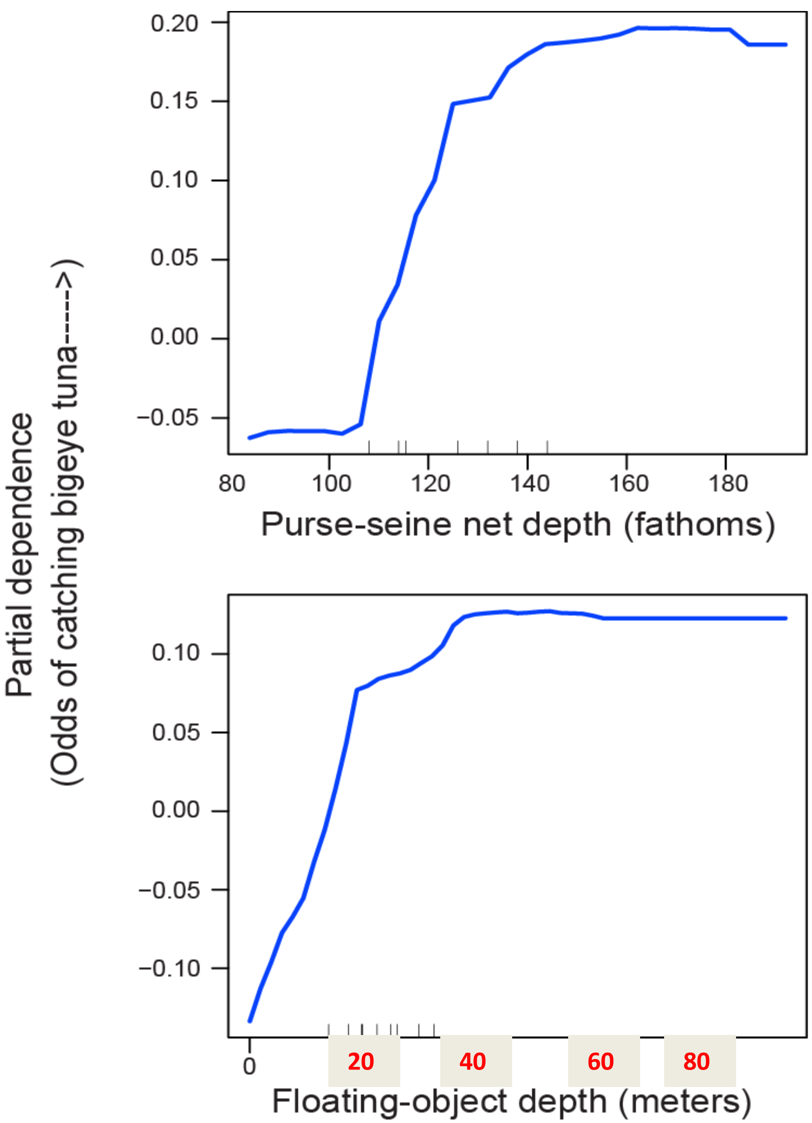
- A random forest classification algorithm was used to predict presence/absence of bigeye tuna catch (= retained + discards).
- Data:
  - Purse-seine floating-objects sets of Class-6 vessels, 2012-2013.
  - Environmental information provided by NASA Jet Propulsion Laboratory (at ~1° area-week resolution).
- 65 predictors used to build the random forest algorithm:
  - Latitude, longitude and month of fishing;
  - gear characteristics (median values): purse-seine net depth, floating-object depth; % object covered with epibiota, proxy for local object density;
  - environmental:
    - current week (SST and SST anomaly, SSS, SSH, MLD, U and V velocities and anomalies, wind speed, probability of fronts);
    - first-differenced values of some variables;
    - lagged quantities (mean, standard deviation, slope), one month and four months, of some variables.

Environmental and gear effects on the probability of catching bigeye



- Fishing location and some environmental effects appear more important than gear effects; many predictor variables are correlated.
- Misclassification errors: presence = 21%; absence = 26% .

Environmental and gear effects on the probability of catching bigeye

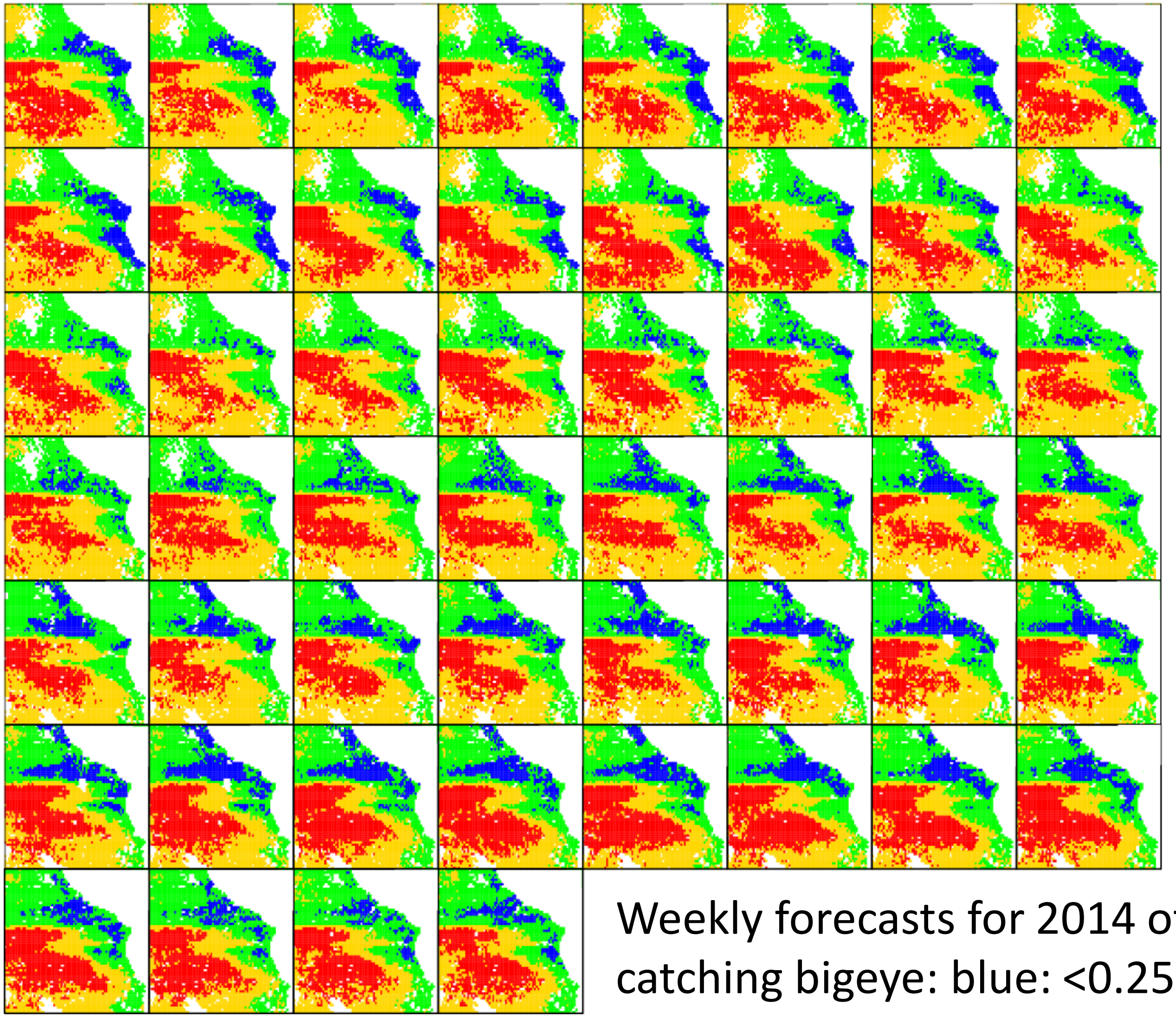


- Overall, the probability of bigeye in the catch increased with deeper nets and floating-objects with greater underwater depth.
- These effects may vary spatially.

An illustration of forecasting areas with high probability of bigeye

- A random forest classification algorithm was used to predict presence/absence of bigeye catch for each week in 2014.
- Each week's random forest algorithm was built with data from the previous two years.
- Predictors: all variables described previously, except gear characteristics.
- Weekly maps show the probability of bigeye tuna (proportion of trees in the forest that predicted presence of bigeye tuna), based on the current week's environmental data.

An illustration of forecasting areas with high probability of bigeye



Weekly forecasts for 2014 of the probability of catching bigeye: blue: <0.25; green: 0.25-0.50; gold: 0.50-0.75; red: >0.75

Summary and Future Work

- A random forest classification algorithm did fairly well at predicting presence/absence of bigeye tuna catch in floating-object sets for 2012-2013.

- This result is consistent with those of previous studies based on floating-object set data from 2001-2005.

- Fishing location and environmental information appear to be more important to correct classification than gear characteristics, but correlations between predictors complicate this picture…

- Weekly forecasts of the probability of catching bigeye tuna could be tested and further developed to aid with efforts to reduce bigeye catch.