IPHC-2017-AM093-05

D. Griffay

Space-time modelling of setline survey data

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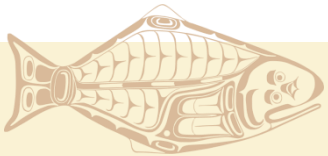
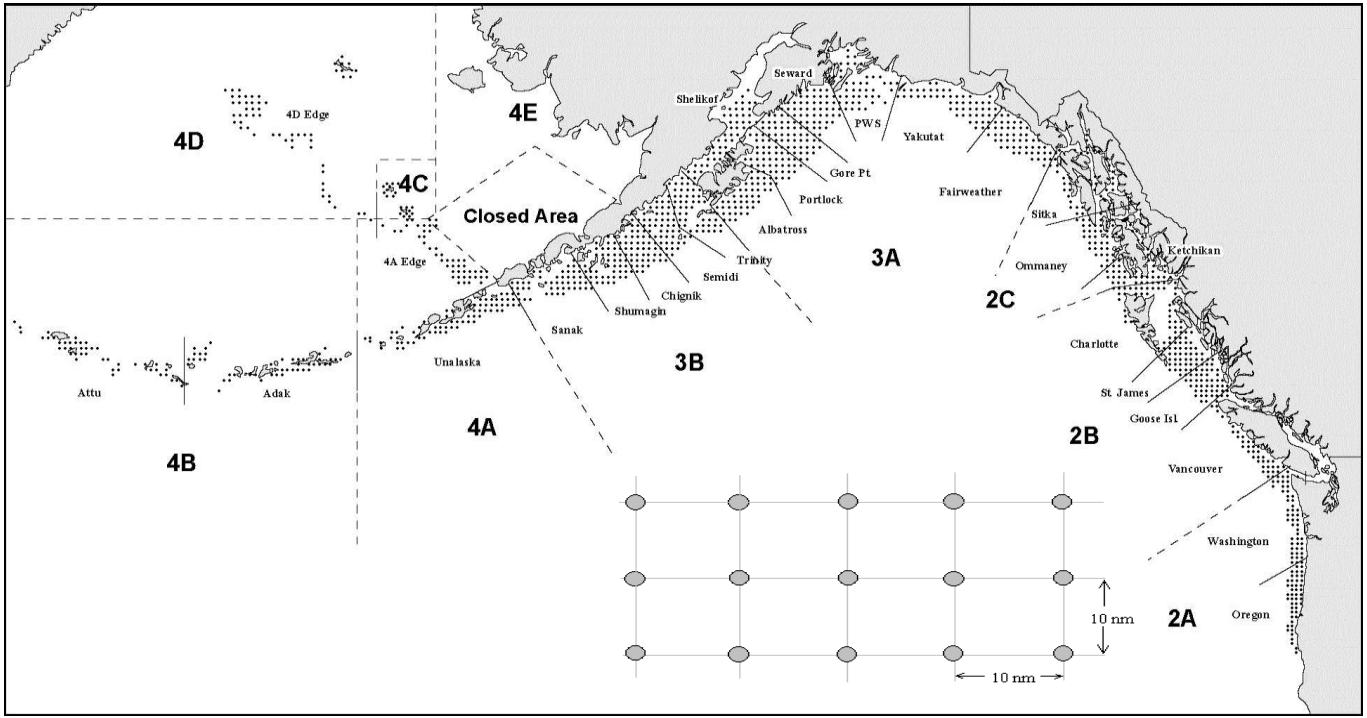
Summary

- In 2016, a space-time modelling approach was adopted to estimate WPUE and NPUE indices
  - Previously we used an “empirical” approach based on direct calculations from observed data
  - New method recommended for adoption by SRB
- Space-time modelling:
  - Reduces random variation in the indices
  - Improves how we deal with incomplete survey coverage
  - Improves estimates of uncertainty
- Results are consistent with old approach
  - Very similar, but smoother, time trends in WPUE and NPUE
  - Some small, but locally important, differences in apportionment results



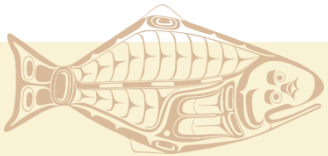
Background

- IPHC standard setline survey
  - Over 1200 annually-fished stations
  - On grid with 10 nmi spacing since 1998



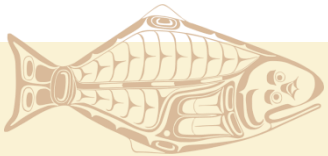
Survey WPUE and NPUE

- Mean survey O32 WPUE and total NPUE are used as indices of halibut density:
  - They index density in each regulatory area
  - Weighted by bottom area to create coastwide indices
- Survey WPUE
  - Provides the most direct comparison with commercial WPUE
  - Used for apportionment
- Survey NPUE
  - Used in the stock assessment



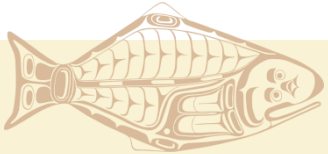
Survey WPUE and NPUE

- Until this year, WPUE and NPUE indices in an area were based on a simple arithmetic mean of station WPUE and NPUE
- Incomplete survey coverage was accounted for by:
  - use of adjustment scalars when there was more complete coverage in at least one year
  - using complementary data from other surveys
  - assuming catch rates in observed regions also applied to unsurveyed regions

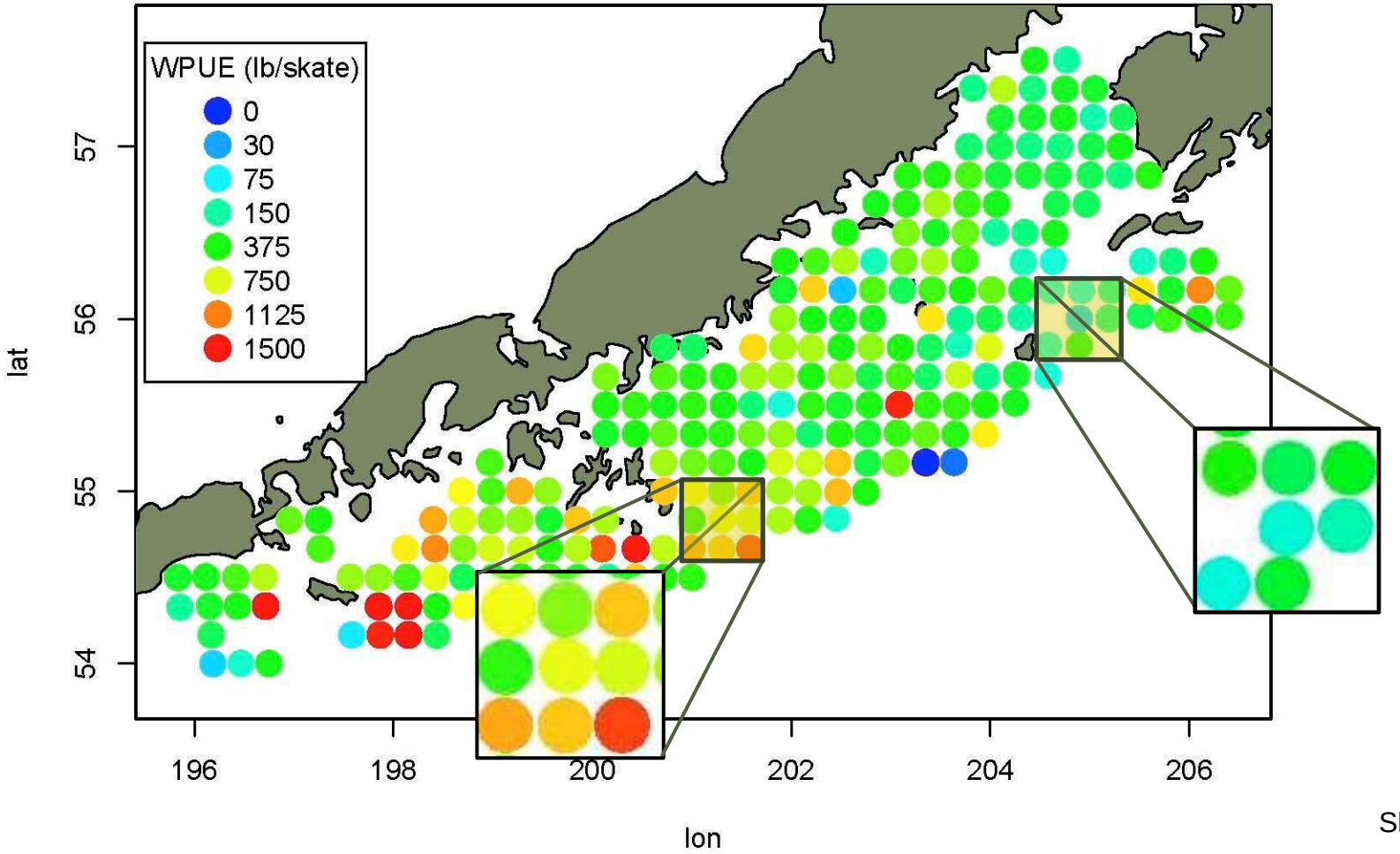


Why fit space-time models?

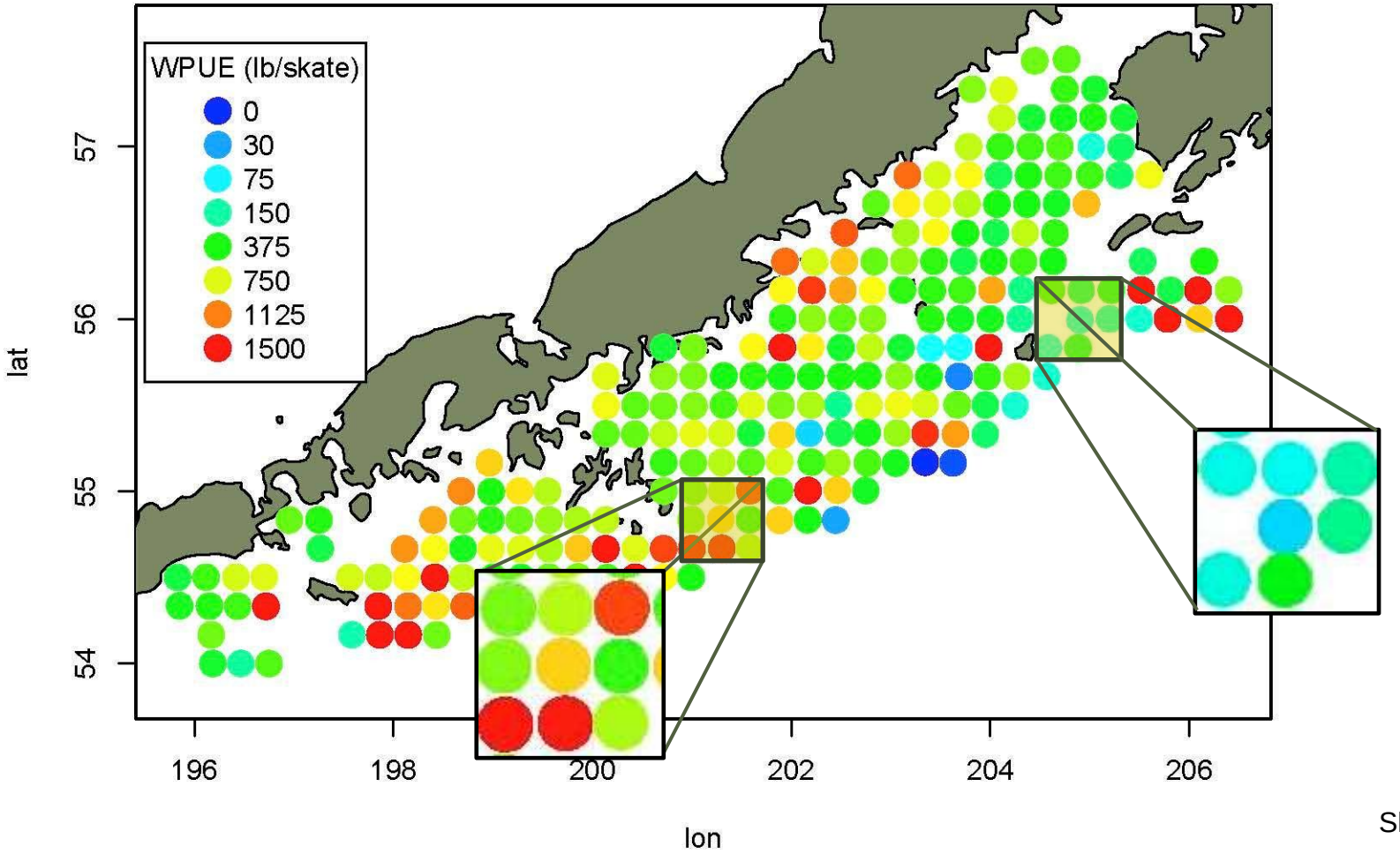
- Uses the same data, but extracts more information from the data
  - Stations close to each other in space are more likely to have similar halibut density than those far apart (spatial dependence)
  - Sets made at a station in consecutive years are more likely to have similar WPUE than those made several years apart (temporal dependence)
- In other words, halibut density is patchy and patches persist with time
- Space-time models can make use of this information to improve estimates of density indices (WPUE, NPUE)



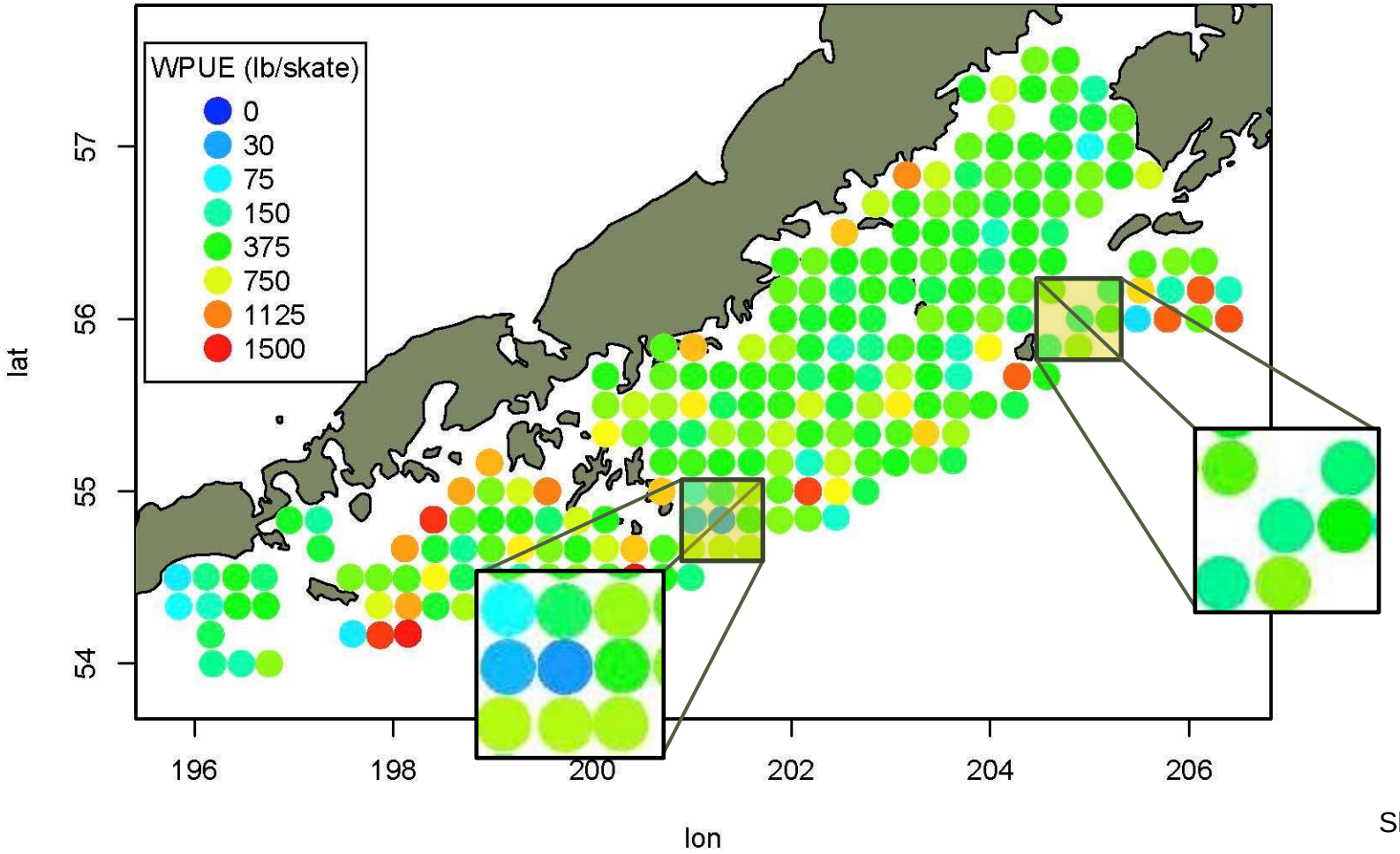
Area 3B observed WPUE 1998



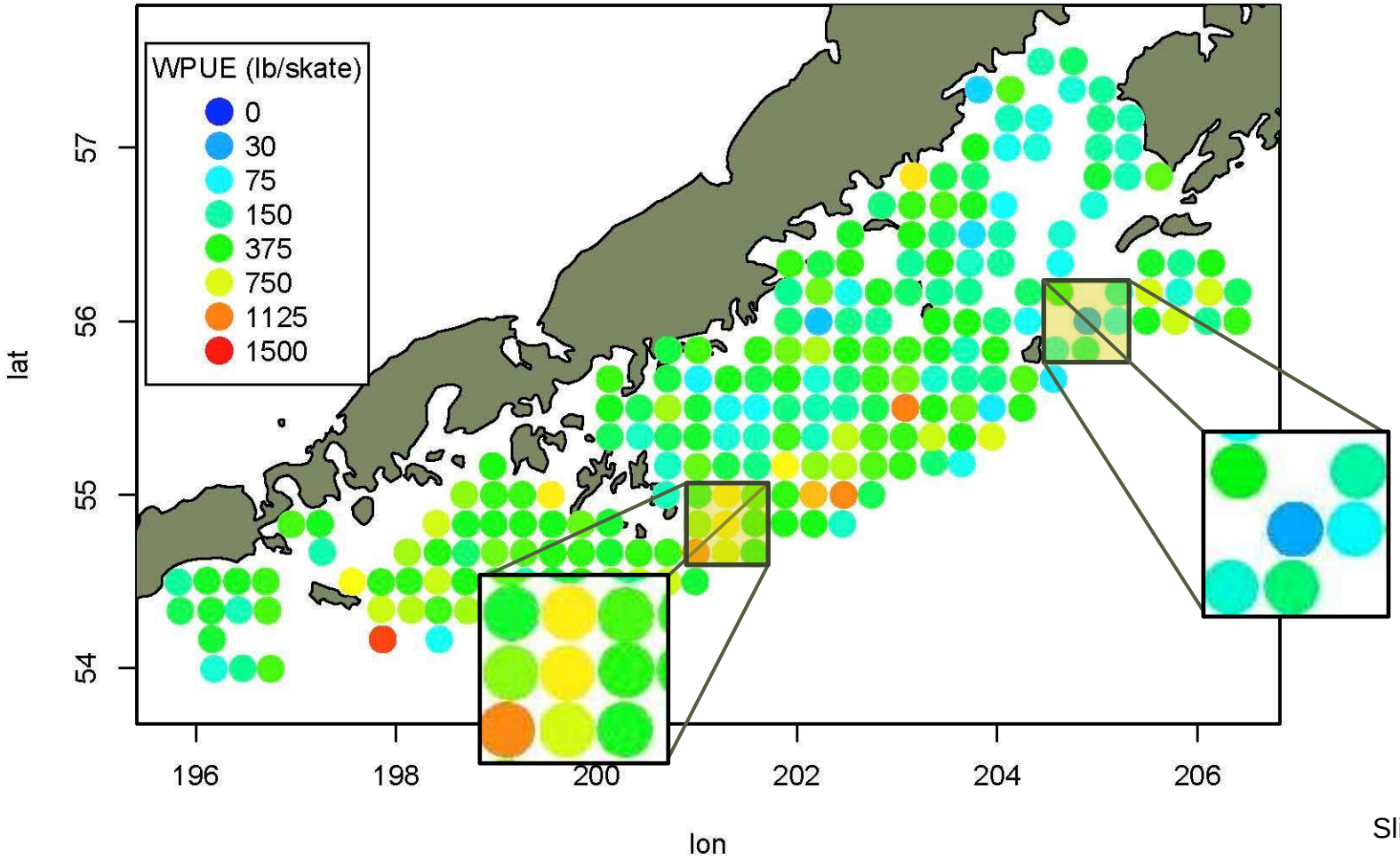
Area 3B observed WPUE 1999



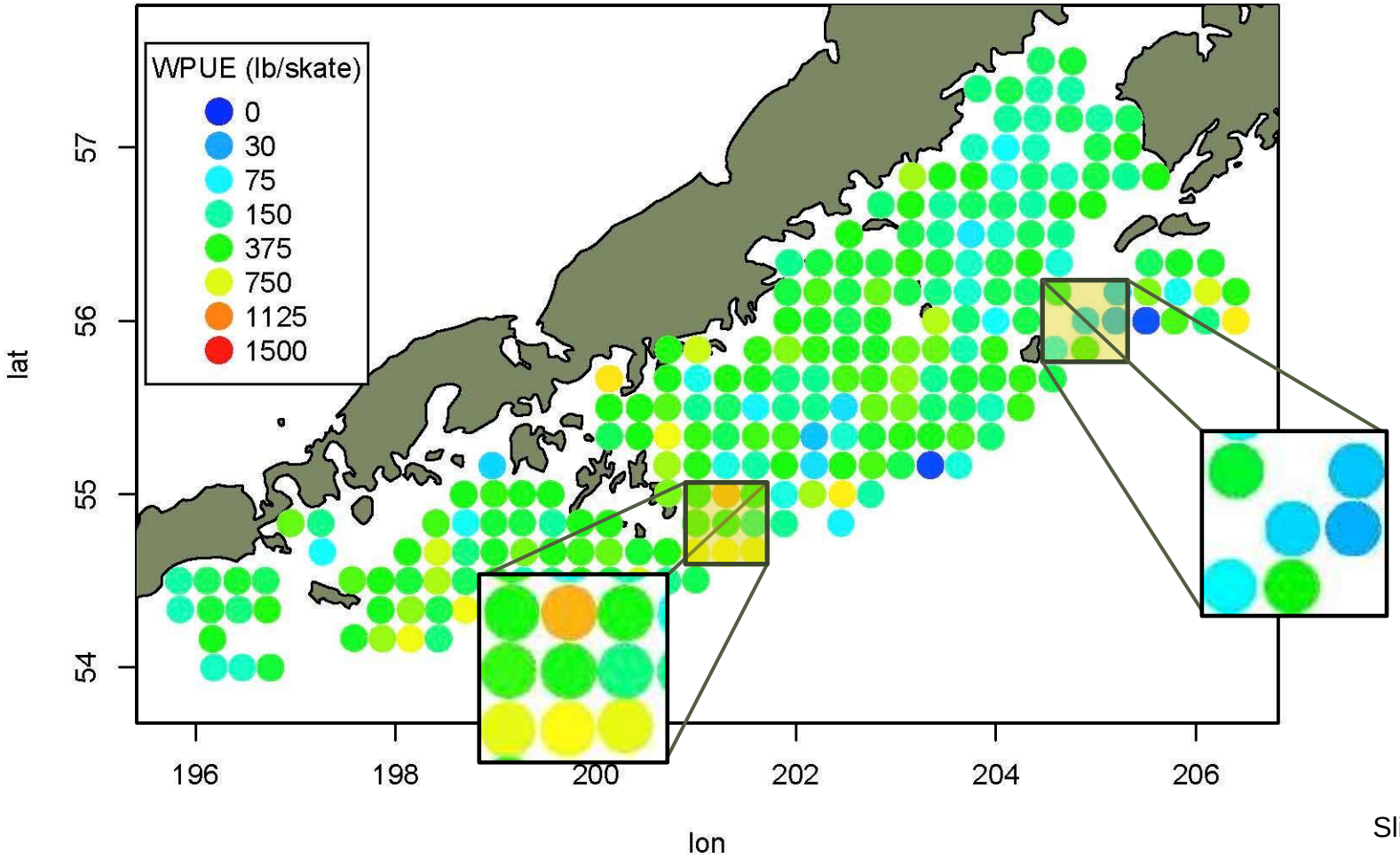
Area 3B observed WPUE 2000



Area 3B observed WPUE 2001



Area 3B observed WPUE 2002

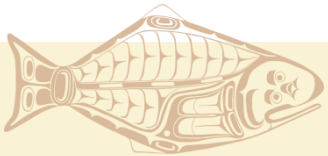


Improving estimation

- Space-time models can improve an estimate of WPUE or NPUE at each station by making use of:
  - data from nearby stations in the same year
  - data from the same station and nearby stations in other years
- Can predict WPUE or NPUE at locations with no data:
  - ineffective stations
  - regions with no survey coverage in a given year

Improving estimation

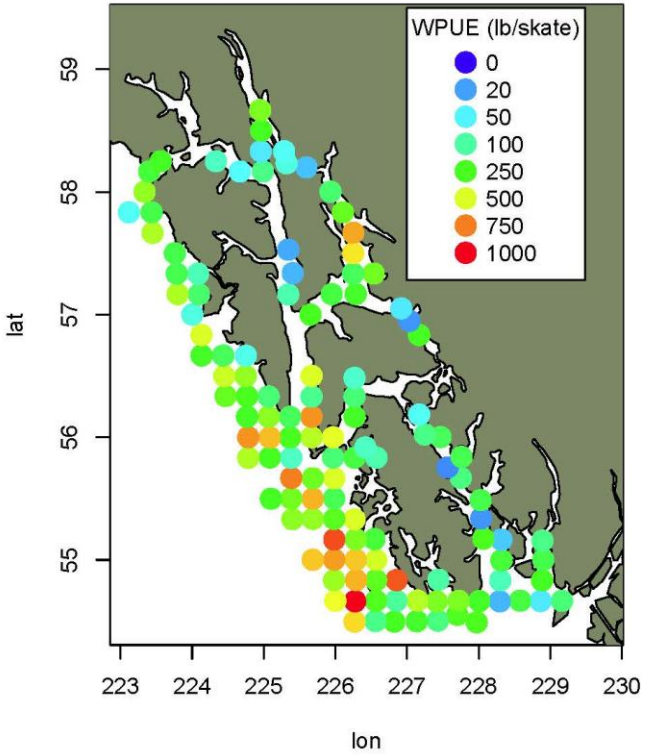
- Estimating the degree of spatial and temporal dependence helps distinguish the underlying halibut density from random variation in halibut catch
  - “Sorts out the signal from the noise”
- Estimation of WPUE and NPUE can be further improved by use of covariates in the models:
  - Depth
  - Year (time trend)
  - Latitude and longitude



Coverage gaps

- Areas that have had an expanded survey (2A, 4A in 2014, 4CDE flats in 2015 and edge in 2016)
  - Model can predict WPUE in years when survey coverage is incomplete
- Areas awaiting expansion (2B, 2C, 3A, 3B, 4B)
  - In areas adjacent to expanded areas (2B, 3B, 4B), deep/shallow data from neighbouring stations (in 2A, 4A) informs the modelling
  - NMFS sablefish longline survey data used to estimate WPUE in deep water (275-400 fm) in 2C, 3A and 3B
  - Otherwise, prediction in coverage gaps is informed by covariate data and data from nearby survey stations

Through modelling we take the observed data…



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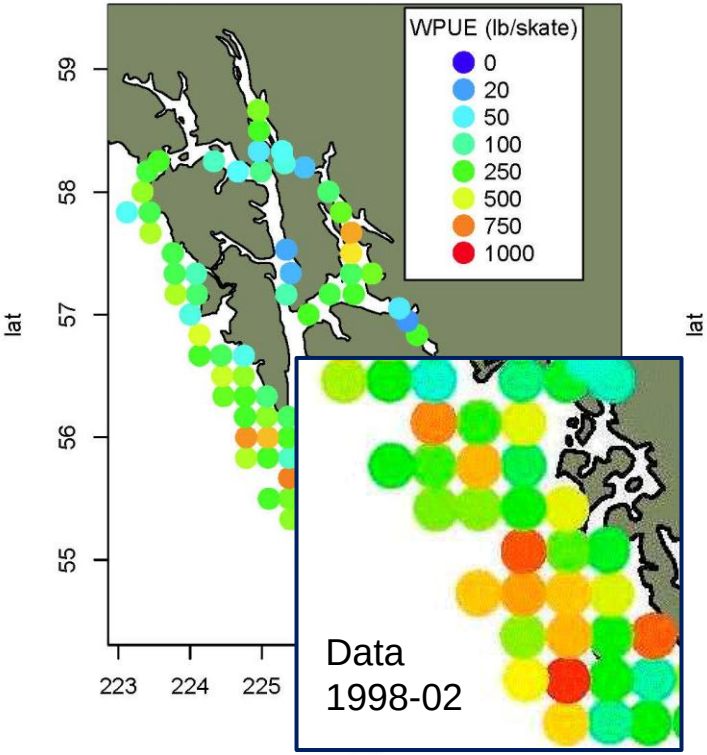
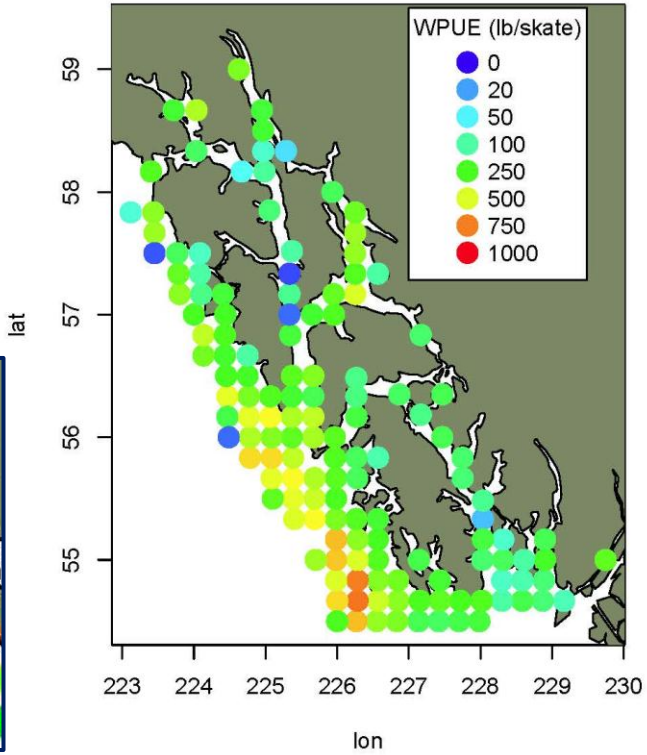


…and produce model estimates



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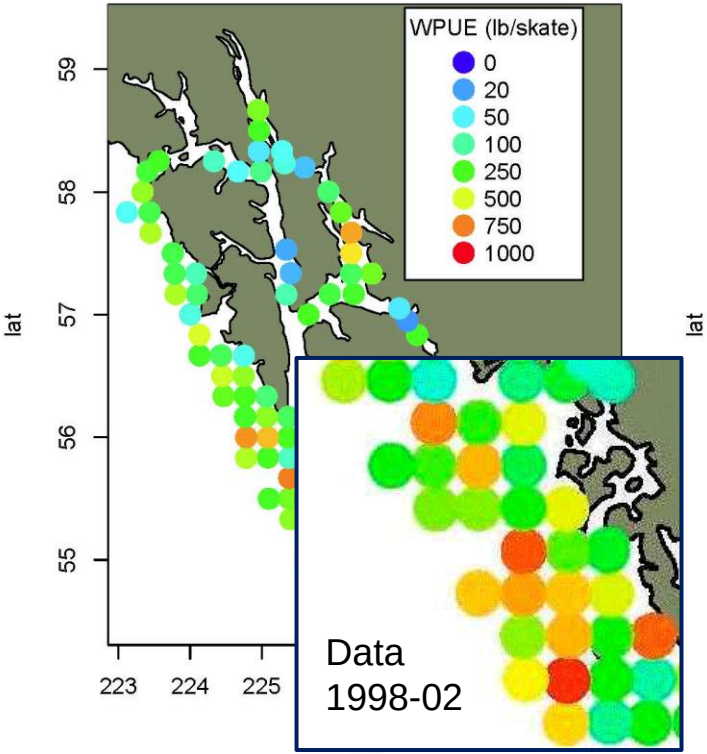

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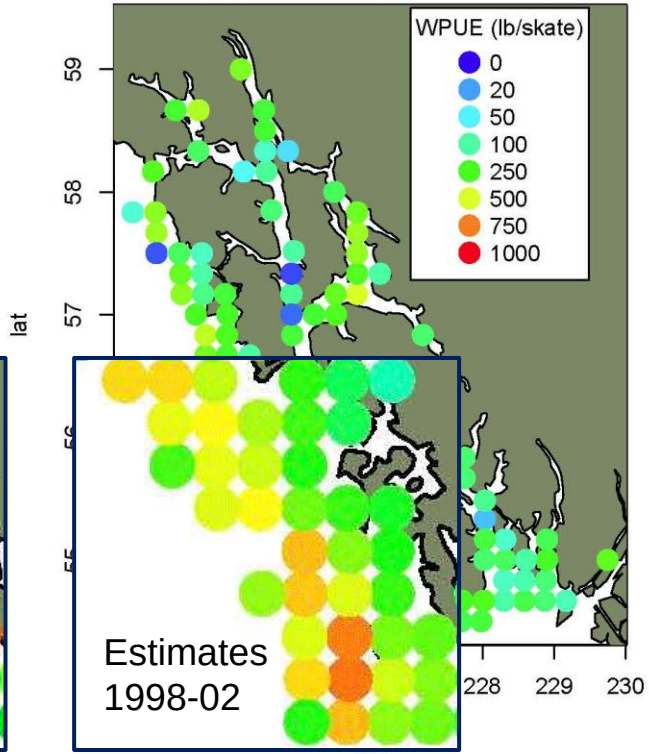
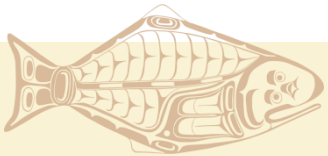


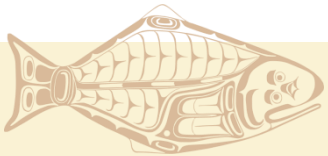
How does space-time modelling improve the density indices?

- Reduces random variation in annual index values
  - We are modelling the underlying mean process, which typically has strong spatial and temporal dependence
- Includes uncertainty due to unsurveyed stations
  - Previously, uncertainty in the various spatial coverage adjustment factors was not accounted for



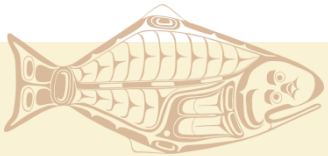
Conclusions

- The modelling approach offers clear advantages over the previous method for estimating WPUE and NPUE from setline survey data.
- In particular, we can dispense with the inelegant and ad hoc collection of adjustments for incomplete spatial coverage, leading to greater clarity and consistency in how these indices are calculated.
- At two meetings in 2016, the SRB recommended the use of the space-time modelling approach starting this year.



WPUE adjustment factors

- Data for the hook competition adjustment are available at the station level
  - Previously an area-wide adjustment was applied
  - We now use adjusted station WPUE and NPUE as data
  - Local effects of competition are now accounted for
  - Effect of this change on WPUE is significant in some areas, e.g.:
    - In Area 2A, competition is greatest in regions of low WPUE
    - In Area 4B, competition is greatest in regions of high WPUE
  - Change supported by Scientific Review Board (SRB)

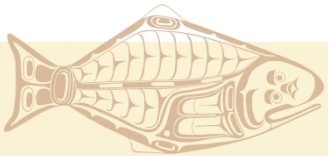


WPUE adjustment factors

- Survey timing adjustment still estimated at regulatory area level
  - SRB recommended some changes in calculation of this adjustment (detailed in the RARA)
  - These changes had little effect on recent indices and apportionment estimates

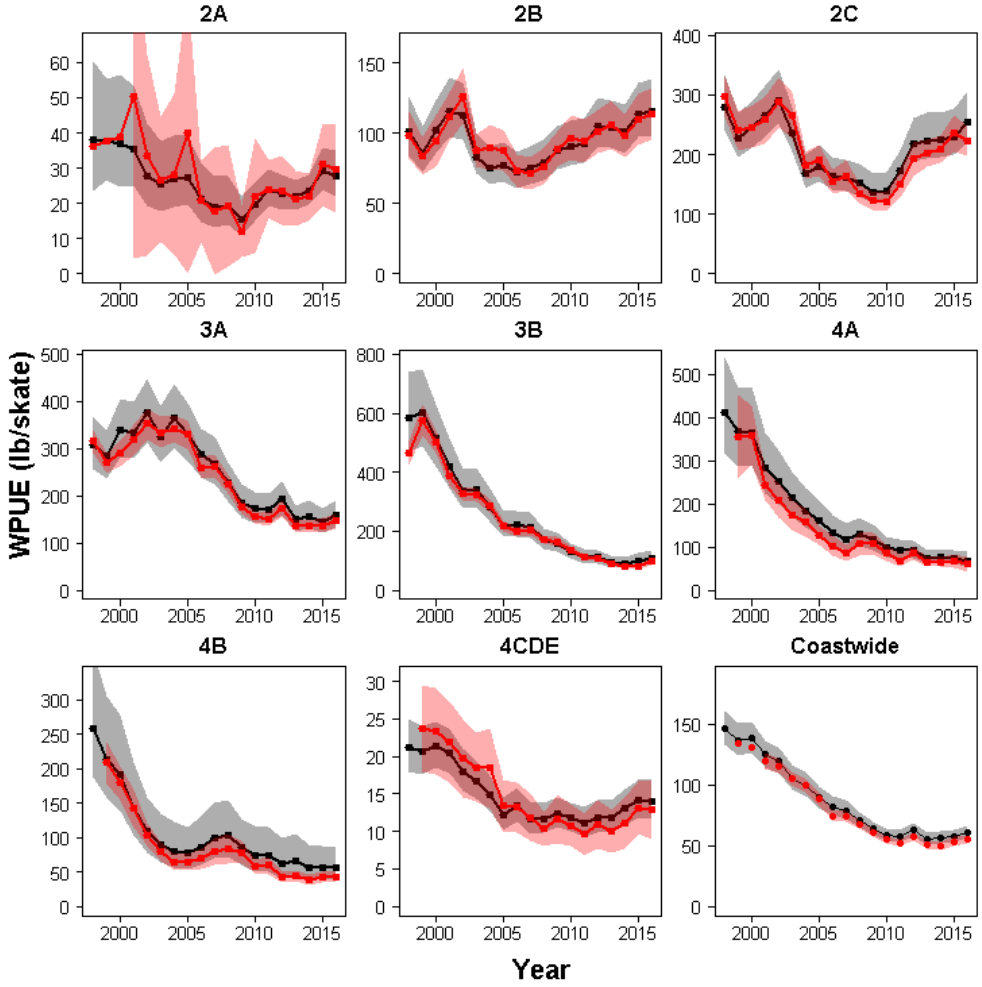
WPUE and NPUE time series

- For each regulatory area in each year, the estimated WPUE and NPUE indices are calculated as averages of model predictions at all previously fished and potential future survey stations.



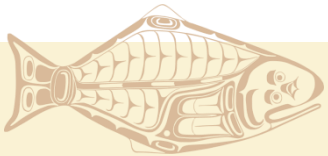
WPUE

Space-time model
Empirical method



Area 4CDE

- Three data sources
  - IPHC setline survey
    - Bering Sea shelf edge (2000-)
      - Expansion in 2016
    - Area 4 islands (2006-)
    - Eastern Bering Sea flats (2006, 2015)
  - NMFS trawl survey
    - Eastern Bering Sea flats (1982-)
    - Northern Bering Sea (2010)
  - ADFG Norton Sound trawl survey
    - Triennial survey in Norton Sound (most recent: 2014)
    - Expansion outside NS in 2006, 2008



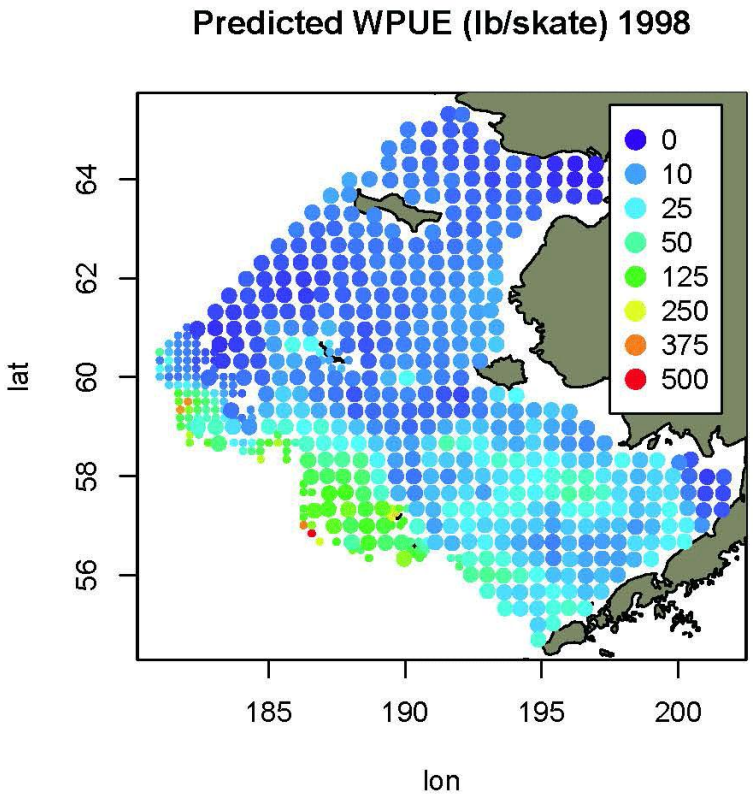
Area 4CDE

- Trawl survey station-level data calibrated and scaled to convert observed trawl catch to predicted setline WPUE
  - Methods presented in recent RARA reports
- Large coverage gaps remain in many years, mainly in the northern Bering Sea

Area 4CDE

- Q: How well would the model predict WPUE in coverage gaps?
  - Prediction at locations far in time and space from data approach mean of entire area
  - To avoid this, we added distance from shelf edge (400 fm contour) as a covariate – SRB suggestion
    - WPUE generally decreases with increasing distance
    - Predictions will combine local data with covariate effects
- A: Model worked very well!
  - Sensible predictions of WPUE in northern Bering Sea in all years

Changes in WPUE distribution with time



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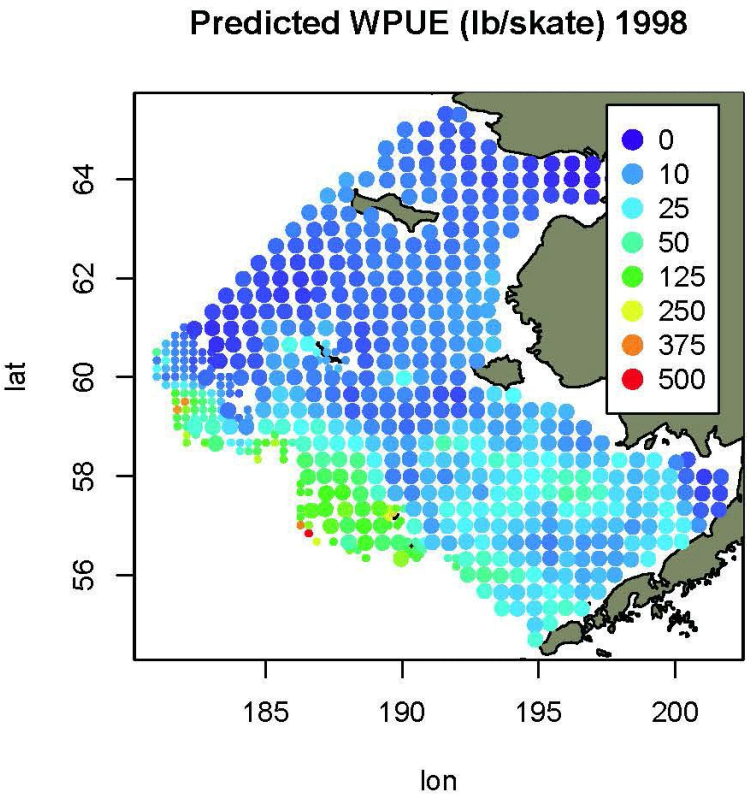
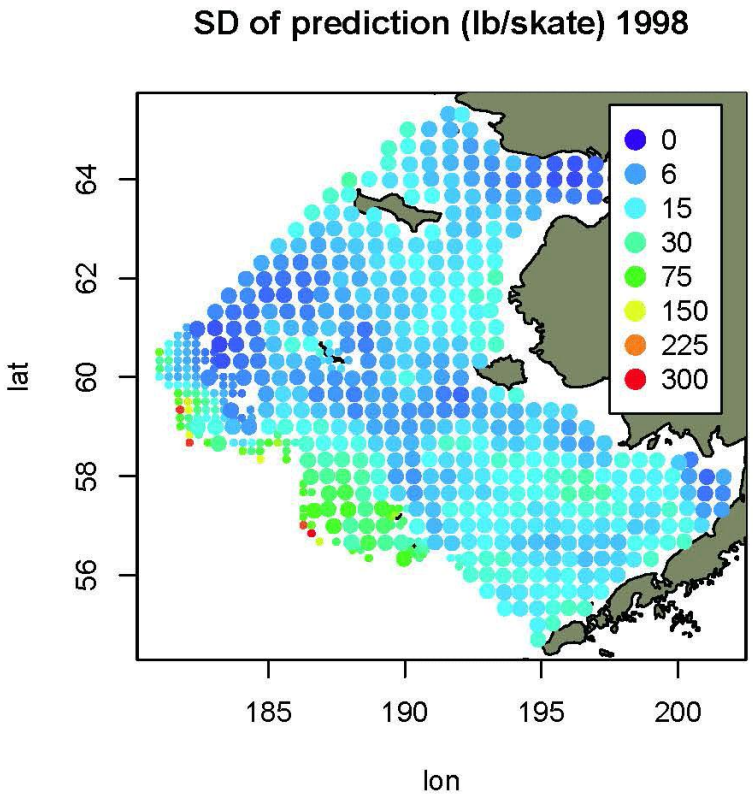
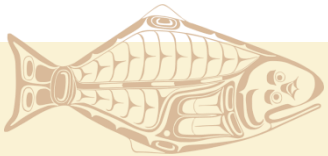


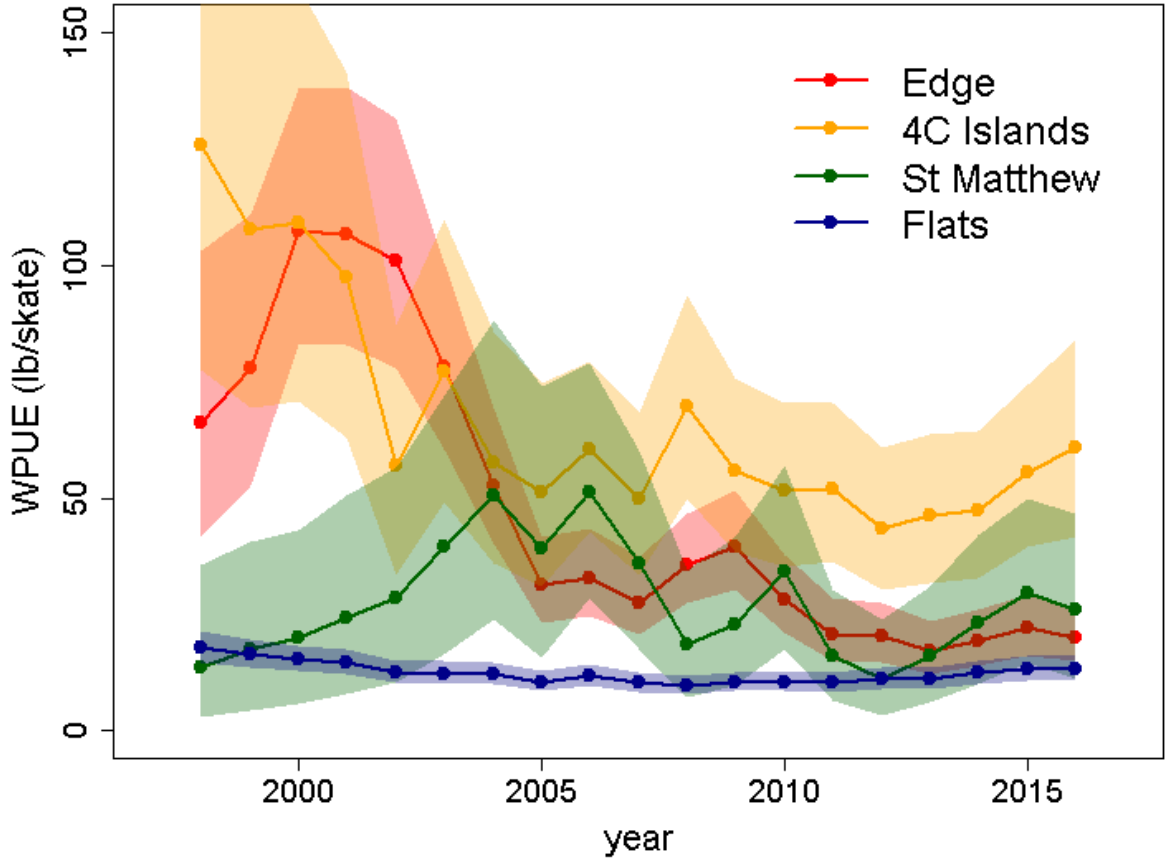


Subarea estimates of WPUE

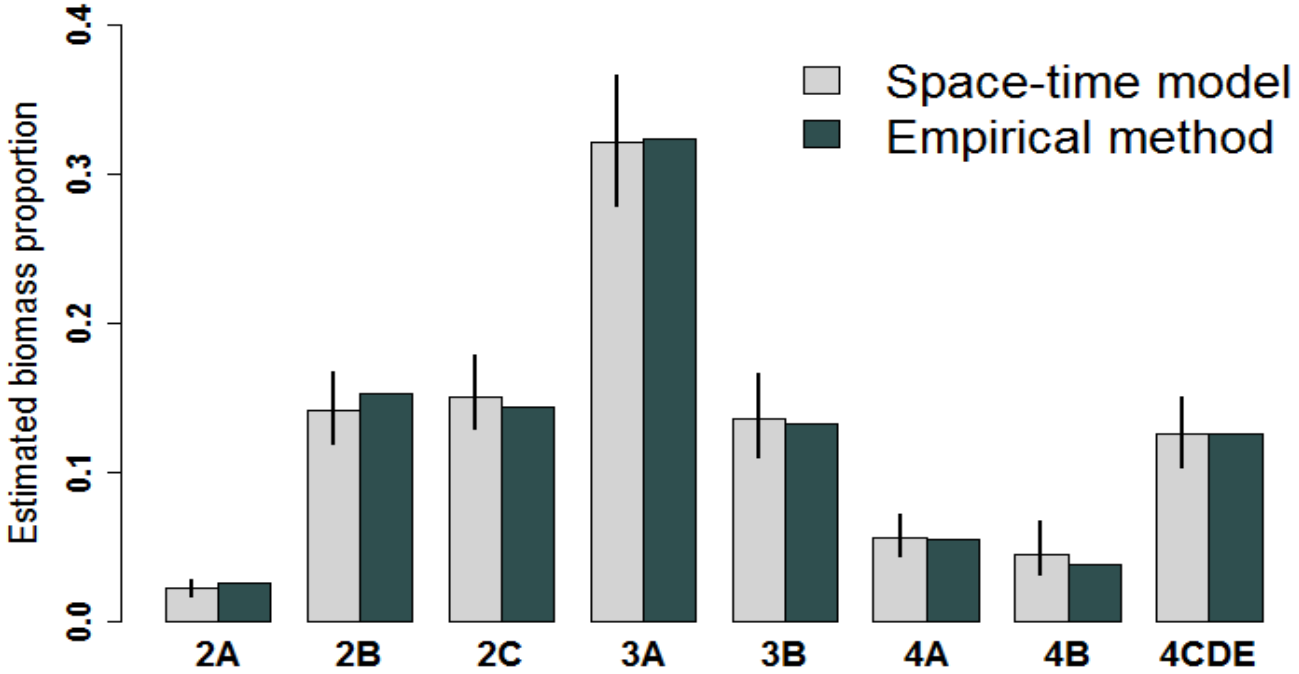
- The new modelling approach makes it easier to compute estimates of mean WPUE for any subarea, along with measures of uncertainty
  - In Area 4CDE, Pribilof Islands' WPUE trend of interest to Area 4C stakeholders
  - In Area 2A, there is interest in estimating WPUE for different subareas (Salish Sea, WA Coast, Columbia River, OR Coast, northern CA)



Area 4CDE WPUE by subarea



2017 apportionment estimates



Final comments

- This is the first year in which a consistent approach has been used to estimate both WPUE and NPUE
  - Previously NPUE used in the assessment did not have the hook competition and survey timing adjustment factors applied
- Use of the space-time model brings us in line with modern analytical methods used elsewhere
- Model estimates will further improve as additional data become available
  - IPHC survey expansions in 2A & 4B (2017), 2B & 2C (2018) and 3A & 3B (2019)
  - Expansion of NMFS trawl survey in northern Bering Sea in 2017