2021 Groundfish Assessment Program Model-based Indices (VAST)

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AFSC-RACE

Objective

Provide model-based estimates of abundance and/or age composition from survey data to stock assessment authors and others, on a similar timeline as design-based estimates.

The Vector Autoregressive Spatio-Temporal (VAST) model was selected based on contemporary research as well as available staff expertise (Thorson 2019)

Production Calendar

Feb
- species requests made via google doc (including species prioritization)
- initial settings agreed upon
- iterating begins

Mar
- Terms of Reference signed

Apr
- hindcasts completed, code and versions frozen

May - Aug
- BT Survey

Aug/Sep
- survey data QA/QC
- frozen VAST code run on final data
- updated outputs produced

Sep
- Groundfish Plan Team presentation

Oct-Nov
- Scientific & Statistical Committee meeting
- Final NPFMC meetings
- Internal Debriefing

Dec - March
- model-based index research

2021 model-based index and age-comp species

Groundfish Abundance Index

EBS & EBS+NBS	GOA
Pollock	Northern rockfish
Pacific cod	POP
Yellowfin sole	Pacific cod
	Pollock
	arrowtooth flounder
	Dusky rockfish
	Northern rock sole
	Southern rock sole
	Flathead sole

Groundfish Age Composition

EBS+NBS
Pollock
Pacific Cod

Crab Abundance Index

Bristol Bay red king crab
EBS snow crab
EBS bairdi crab

Contributors

RACE

- Lewis Barnett*
- Jason Conner*
- Cecilia O’Leary*
- Paul Von Szalay
- Madison Hall
- Zack Oyafuso
- Caitlin Allen Akselrud
- Stan Kotwicki
- Elaina Jorgensen
- Emily Markowitz
- Jon Richar (crab)

HEPR

- James Thorson

REFM

- Ben Williams
- Pete Hulson
- Kalei Shotwell (ESP)
- Martin Dorn
- Kari Fenske
- Meaghan Bryan
- Cole Monnahan
- Jim Ianelli
- Grant Thompson
- Ingrid Spies
- Anne Hollowed
- William Stockhausen (crab)
- Cody Szuwalski (crab)

*** Primary GAP contact for EBS/NBS or GOA/AI**

Production research

The Vector Autoregressive Spatio-Temporal (VAST) model was selected based on contemporary research as well as available staff expertise (Thorson 2019)

Current baseline settings selected from Thorson *et al.* 2021

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journal homepage: www.elsevier.com/locate/fishres

ELSEVIER

The surprising sensitivity of index scale to delta-model assumptions: Recommendations for model-based index standardization

James T. Thorson [a,*], Curry J. Cunningham [b], Elaina Jorgensen [c], Andrea Havron [d], Peter-John F. Hulson [e], Cole C. Monnahan [f], Paul von Szalay [c]

Research Dec. 2020-present

1. Model comparisons for Pacific Ocean perch (Hulson)
    a. Discussed in POP SAFE
2. Model comparisons for Bering Sea Pacific cod (Thompson)
    a. Discussed in BS-Pcod SAFE
3. Cold pool extent index (Britt)
    a. Discussed next...

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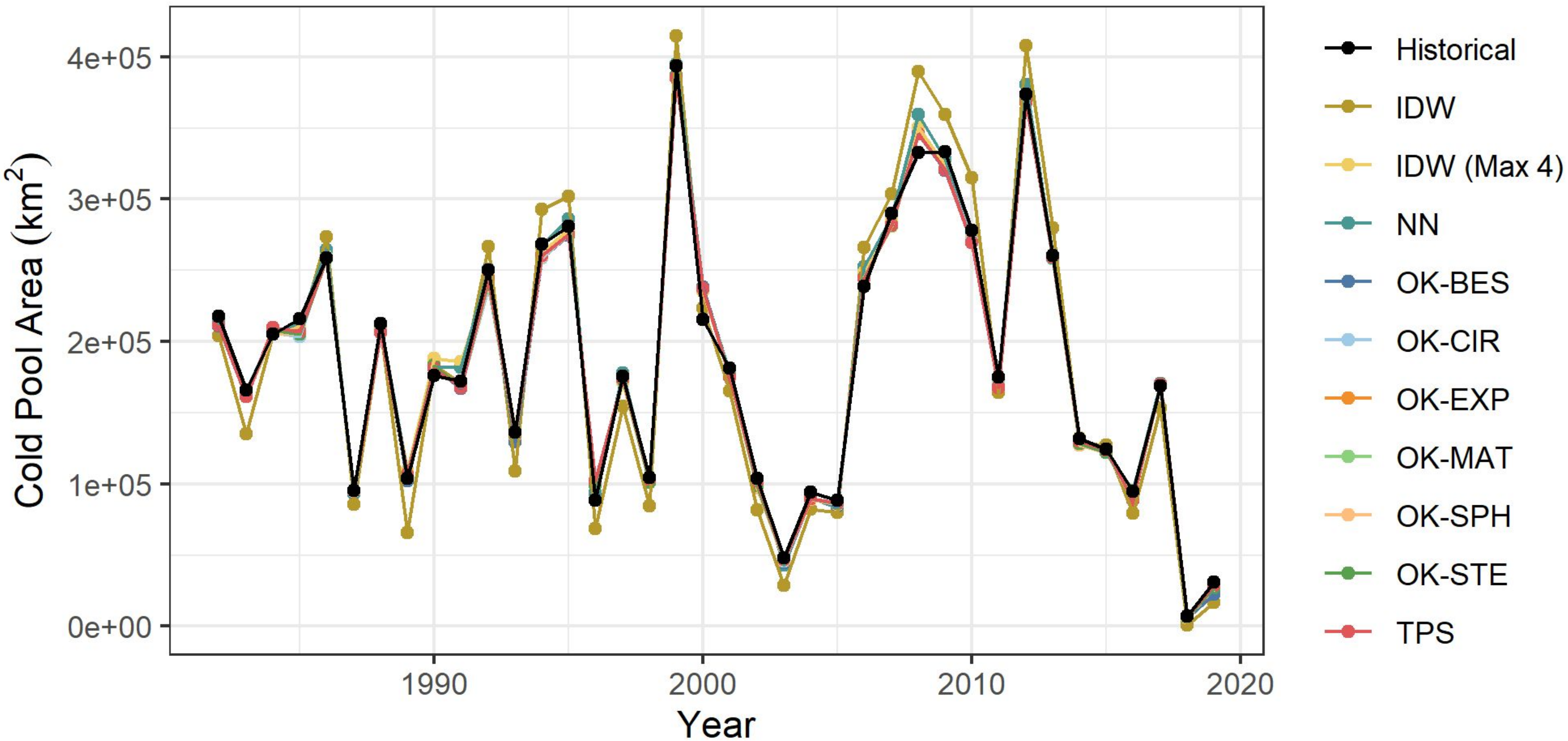
Cold pool extent index update

- CPI computations updated to improve reproducibility
  - Compared historical index to 10 interpolation approaches
  - Estimates are very similar to original index



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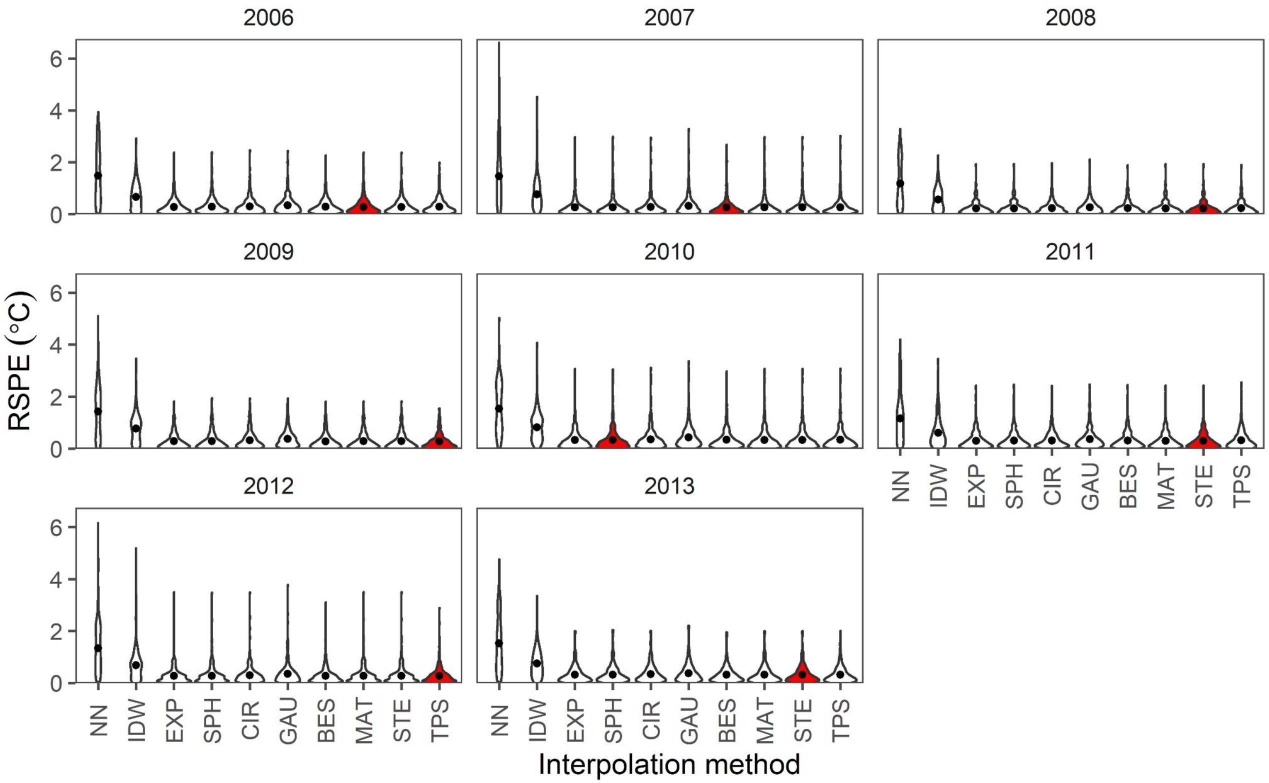
Cold pool extent index update

- Compared performance with leave-one-out cross-validation
  - In most years IDW performed poorly; ordinary kriging with Stein's Matern best and will be the method used this year



Direction for index production

- open framework (GitHub)
- formal bridging step (from previous to this year's model and data)
- review/formalize data filtering
- fine-tuning results review

  - goodness of fit diagnostics (Cole Monnahan & Andrea Havron)

  - index recommendation/rejection criteria to be co-developed with stock assessment authors
- CPI: document and review methods, potentially account for variation in survey timing

Proposed research

1. **Improving indices**
   a. linking model-based indices with environmental drivers
   b. including additional data (ADF&G Norton Sound, etc.)
   c. species-specific model settings (could do 1 species/region/year)
   d. increase model resolution (# knots)
2. **Understand/explain any differences between model- & design-based indices**
   a. untrawlable habitat interpolation
   b. GOA depth cut-off (700 m)
3. **Alternate index models**
   a. run suite with alternative estimators: GAM (Casper Berg) or sdmTMB (Sean Anderson)
4. **Continued methods research**
   a. Estimation of survey age sampling methods & missing data
   b. Barrier-SPDE models
   c. covariates affecting decorrelation rates
   d. accuracy/precision of variance estimates
5. **Diagnostics of fit & formalizating criteria for rejection or acceptance of indices**

Questions for the Plan Team

Identifying the optimal model for every species will be a long-term challenge (time & personnel & research)

- **Prioritization of**
  - research paths (rank slide 11)
  - stocks
  - model-based age or length comps
  - regions (e.g., subregional GOA, NBS)

- **Criteria for including non-standard samples**

  (e.g., 2001/2005/2006 bottom trawl samples in northern extension; 1982/1985/1988/1991 bottom trawl surveys in NBS, Norton Sound ADF&G data, net mensuration missing data)

  - when acceptable to use different observations of model- vs. design-based?
  - table of non-standard tows be useful?
  - best approach to determining consequences of including/excluding nonstandard data (e.g., abundance CVs, assessment retrospectives)

Questions?

Contact

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Extra Slides

Benefits and drawbacks of VAST

Benefit (ranked large to small)
Combine multiple data streams (i.e., to avoid bias arising from differences in area-sampled)
Disciplined approach to spatially unbalanced data (propagates variance without "ignoring" missing data)
Account for portion of variance associated with randomized sample location
Improve "statistical efficiency" (decrease standard errors) for limited data
Improved communication and intuition by visualizing survey products on a map
Single approach that works for many uses; improved efficiency for methods review

Drawback	Response to drawback
Potential to introduce bias	• Simulation suggests bias in trend is small/nonexistent • Simulation suggests bias in scale is small
Results are model-based (so affected by user decisions)	Pre-define terms of reference (TOR)
Complicated to use and explain	Simplified user-interface in progress
Many decisions to make	Decision guidance available

GOA and BS catchability coefficients (Thorson *et al.* 2021)

Table 1

All stocks included in analysis, including the scientific and common name of the assessed species, the region for each stock (GOA = Gulf of Alaska, EBS = Eastern Bering Sea), and a reference for the stock assessment. We also list how the catchability coefficient for the bottom trawl survey is treated (either fixed at a value *a priori*, estimated with a prior distribution, or estimated freely without a prior distribution), the coefficient of variation for the associated prior when estimated using one, and whether catchability is varying over time either through a time-dependent parameterization or implicit variation due to estimated time-varying selectivity.

Scientific name	Common name	Region	Assessment reference	Treatment of catchability coefficient	CV of prior on catchability coefficient	Time-varying catchability
Atheresthes stomias	Arrowtooth Flounder	GOA	Spies et al., 2019a	Fixed	–	Not time-dependent
Microstomus pacificus	Dover Sole	GOA	McGilliard et al., 2019	Fixed and estimated with prior	85 %	Time-blocks (fixed one block, estimated one block)
Hippoglossoides elassodon	Flathead Sole	GOA	Turnock et al., 2017	Fixed	–	Not time-dependent
Sebastes polyspinis	Northern Rockfish	GOA	Cunningham et al., 2018	Estimated with prior	45 %	Not time-dependent
Gadus macrocephalus	Pacific Cod	GOA	Barbeaux et al., 2019	Estimated freely	–	Time-dependent through selectivity
Sebastes alutus	Pacific Ocean Perch	GOA	Hulson et al., 2019	Estimated with prior	45 %	Not time-dependent
Lepidopsetta polyxystra and *L. bilineata*	Northern and Southern Rock Sole	GOA	Bryan, 2017	Fixed	–	Not time-dependent
Gadus chalcogrammus	Walleye Pollock	GOA	Dorn et al., 2019	Estimated with prior	10 %	Not time-dependent
Pleuronectes quadrituberculatus	Alaska Plaice	EBS	Wilderbuer and Nichol, 2019	Fixed	–	Not time-dependent
Beringraja binoculata	Alaska Skate	EBS	Ormseth, 2018	Fixed	–	Not time-dependent
Atheresthes stomias	Arrowtooth Flounder	EBS	Spies et al., 2018	Estimated freely	–	Time-dependent through annual deviations related to bottom water temperature
Reinhardtius hippoglossoides	Greenland Turbot	EBS	Bryan et al., 2018a	Fixed	–	Not time-dependent
Atheresthes evermanni	Kamchatka Flounder	EBS	Bryan et al., 2018b	Estimated freely	–	Time-dependent through annual deviations related to bottom water temperature
Lepidopsetta polyxystra	Northern Rock Sole	EBS	Wilderbuer et al., 2018	Fixed	–	Not time-dependent
Gadus macrocephalus	Pacific Cod	EBS	Thompson and Thorson, 2019	Estimated freely	–	Time-dependent through selectivity
Hippoglossus stenolepis	Pacific Halibut	EBS	Stewart and Hicks, 2018	Estimated freely in areas-as-fleets model	–	Not time-dependent
Gadus chalcogrammus	Walleye Pollock	EBS	Ianelli et al., 2019	Estimated freely	–	Time-dependent through selectivity
Limanda aspera	Yellowfin Sole	EBS	Spies et al., 2019b	Estimated with prior	90 %	Time-dependent through annual deviations related to bottom water temperature
Anoplopoma fimbria	Sablefish	GOA and EBS	Hanselman et al., 2019	Estimated with prior	30 %	Not time-dependent

Papers testing spatio-temporal model performance (particularly VAST)

Shelton et al. 2014 CJFAS
- Case study demonstration of improved precision relative to design-based

Thorson et al. 2015 ICES JMS
- Simulation testing for estimating indices of abundance

Thorson et al. 2017 CJFAS
- Simulation testing for fishery-dependent standardization

Cao et al. 2017 CJFAS
- Case study comparison of design and spatio-temporal index in Gulf of Maine northern shrimp assessment

Thorson and Haltuch 2018 CJFAS
- Simulation testing for estimating age/length composition data

Grüss et al. 2019 Fish. Res.
- Blinded experiment with independently made operating model

Johnson et al. 2019 Fish. Res.
- Simulation experiment comparing model performance for VAST when missing covariates

Brodie et al. 2020 Ecography
- Biologically motivated operating model, comparing VAST, random forest, and GAMs

Maunder et al. 2020 Fish. Res.
- Discussion of importance for spatio-temporal standardization of fishery-dependent CPUE

O'Leary et al. 2020 Fisheries Oceanography
- Spatio-temporal model-based estimates of a biomass index and age composition for EBS + NBS pollock can facilitate rapid changes in stock assessment structure in response to climate-driven shifts in spatial distribution

WKUSER ICES Workshop Report. 2020. (http://www.ices.dk/sites/pub/Publication%20Reports/Forms/DispForm.aspx?ID=36905)
- Several participants are working on papers comparing design-based and VAST estimates in a simulation framework for GOA and EBS

Thorson et al. 2021. Fish. Res.
- Simulation and case study showing that gamma distribution (and Tweedie model) match scale of design-based estimator on average

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Cold pool extent index update

- CPI computations updated to improve reproducibility
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