NOAA FISHERIES

Stock Synthesis History

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History - 1984

- Synthesis – Whole is Greater Than Sum of Parts
- Coded in FORTRAN, numerical derivatives with IMSL library
- Specific model for anchovy off California
- Low F, diverse data
- Temperature effects on maturation and selectivity
- M = f(predator abundance)
- Absolute and relative abundance surveys
- Fleets-as-areas for US and Mexican fisheries

Synthetic Estimates of Historical Abundance and Mortality for Northern Anchovy - 1984

Abstract.-The stock synthesis model combines the analyses of catch, abundance, and age composition data. The model seeks the most likely time series of abundance and mortality, and distributes the residual error among all types of data according to each type's consistency with the synthetic estimates. The data for northern anchovy includes two independent fisheries, an auxiliary source of age-composition data, a 6-year time series of accurate, calibrate spawning biomass measurements by the egg-production method (EPM), and longer time series of acoustic biomass and CalCOFI ichthyoplankton. Specific biological relationships in the northern anchovy model are an influence of chub mackerel on natural mortality, and an influence of ocean temperature on patterns in age-specific availability and the fraction of I-year-old fish that are mature and contributing to the larval index. The synthetic estimates of spawning biomass since 1980 typically are within 15% of the measurements made by the EPM. This high precision demonstrates the consistency between change in biomass measured by the EPM and changes expected from recruitment information in the age-composition data. Consistency between the other biomass indexes and age-composition data were lower. Nevertheless, the other biomass indexes are valuable for defining trends in the estimated 33-year time series.

History - 1988

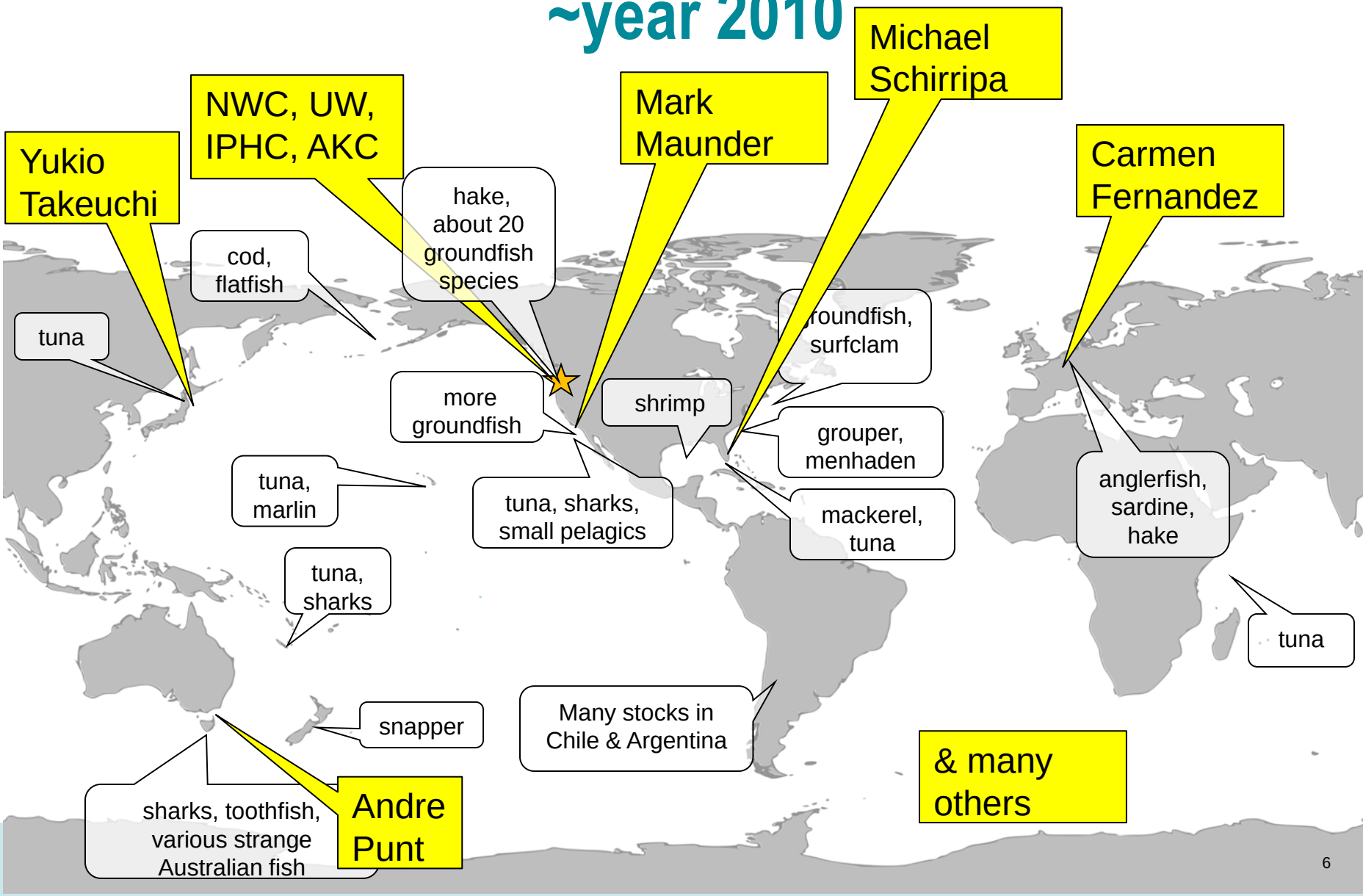
- **Two generalized models coded in FORTRAN**
  - SYNL: Size-age structured, allows size and age selectivity, estimates growth parameters
  - SYNA: Age-area structured, empirical body weight input, age selectivity, allows multiple areas with estimable movement rates
- **Target species: west coast groundfish**
- **Long-lived, some 50+ yr old fish still in data**
- **Weak historical data, except catch, but discarding significant**
- **More size data than age data; ageing imprecise and biased**
- **Expand use to most west coast species by late 1990s**

History – 2003

- **Generalized model coded in C++ with ADMB**
  - codename: Isabel

  - Based on Punt & Cope Cabazon model
- **Merged and expanded features for age/size/area**
- **Target species: diverse**
- **Expansion beyond west coast groundfish growing**

Stock Synthesis Diaspora & Evangelicals ~year 2010



History – 2010s

- Expansion of r4ss
- Public web-based forum created
- National, international, and web-based trainings
- 100s of stocks now assessed with SS

SS International Courses

- Ian Stewart, Ian Taylor, Chantel Wetzel, Michael Schirripa, Jason Cope, Melissa Haltuch, Juan Valero, Alan Hicks, others

Exploring SS Models for South American Stocks

2014 - Chile
Juan Valero,
Melissa Haltuch,
Billy Ernst

Benefits of Stock Synthesis

- Flexible range of options for many population processes
- Integrates many sources of data
- Propagates uncertainty well
- Works well from very simple to very complex models
- Widely used
- Evolving based on decades of development and exploration

Benefits of widespread use (of any modeling platform)

- Bugs less likely to escape notice
- More comparison with other models
- More development of associated tools (e.g. for making plots)
- Facilitates sharing knowledge
  - common language among many scientists
  - more advice on building models
  - easier to understand each others' results

BACK-UP SLIDES

SS History - 1984

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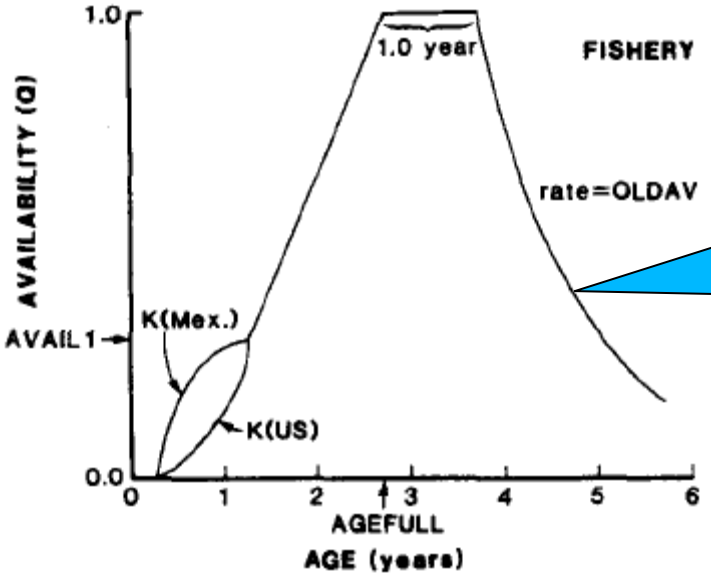
Dome-Shaped Selectivity



Temperature effect on slope parameter

Ageing Error

Age-Determination Variability

Variance in age determination cannot be avoided and has the effect of smearing the sampled age composition as it becomes the observed age composition. A small misaging percentage, say 10%, has little effect on a good year class, but could double the apparent abundance of an adjacent small year class. In the SS model, the per-

Likelihood Basis

Relative Emphasis on Data Types

The overall log-likelihood function, L, is a weighted sum of the log-likelihoods for each type of data (four age-composition types, three abundance types):

$$L = \sum_{t=1}^{7} \text{EMPHASIS}(t)l(t).$$

EMPHASIS(t) is specified by the user.

And with a whole paragraph on shortcomings of multinomial as approach for log likelihood of composition data

Estimation

The search for the best parameter values was based on quadratic hill climbing (Goldfeld and Quandt 1972), which is a modification of Newton's method, and included a Hessian matrix scaling described by Conway et al. 1970. The vectors of first (dX) and second (d^2X) derivatives of L with respect to each value of the parameter X were numerically evaluated in the region around the current estimates of the parameters (±5% of X). The Hessian matrix, H, of mixed partial derivatives, which includes the d^2X on its main diagonal, also was calculated. The vectors of

approach. Each evaluation of the overall log-likelihood function, L, takes about 3 s on an IBM PC/AT computer. Convergence of the complete model takes about 4 h, even if the numerous mixed partial derivatives are recalculated only when the absolute value of the previous estimate of CORR (i,j) was greater than a uniform random value (0–0.3). Second derivatives and large mixed

ADMB does not use the Hessian during estimation, so creeps along ridges

Model complexity has increased and "tolerable" runtimes remain about the same

Built by hand in a workshop at LaJolla

Anchovy SS Results