NOAA FISHERIES

Northwest Fisheries Science Center

Endangered salmonid trend assessments

Approaches for using multi-stock data to improve trend assessment

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18 Sept 2015

Endangered Species Act (ESA)

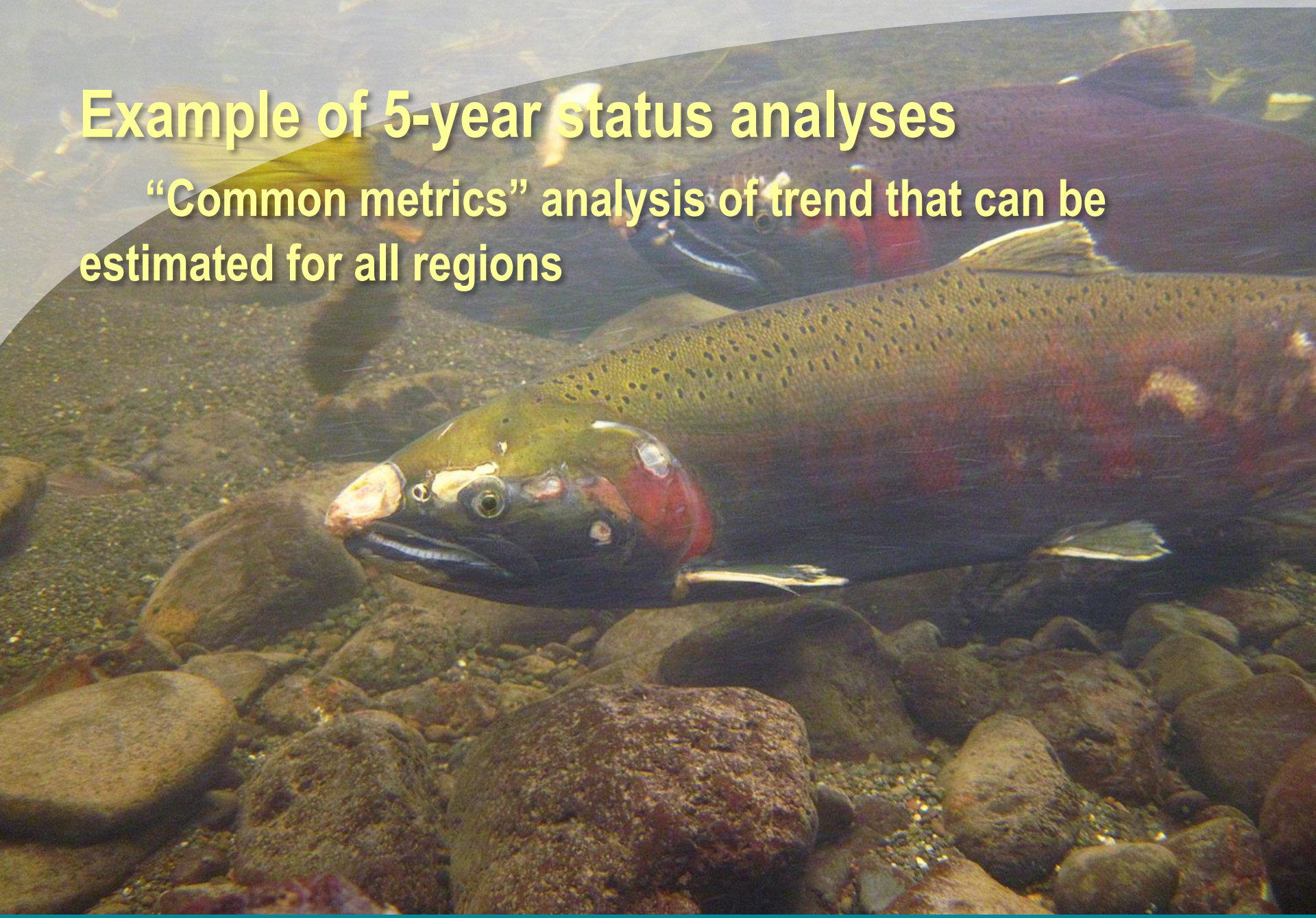
- "Listing" of species (or specifically distinct population segments) under the ESA provides extensive protections
  - Recovery goals set
  - Critical habitat established
  - 5-year status reviews
  - Unlike for harvested species, determination of MSY is not part of the management analyses since listed species are not harvested (commercially) typically

Status assessments for listed salmonids

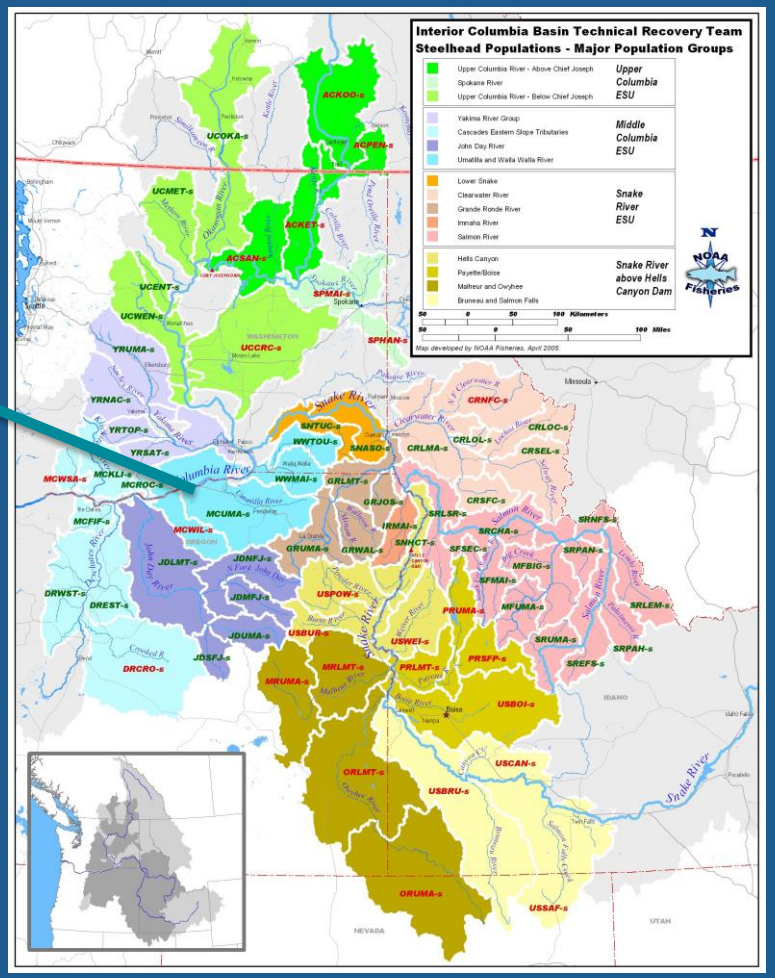
- **Monitoring data collected on spawning abundance**
  - Red counts
  - Dam/weir counts
  - **Data have high amounts of noise**
  - **Data have gaps (missing years)**
- Survival data
- Juvenile abundance data
- Age of spawning data

Example of 5-year status analyses

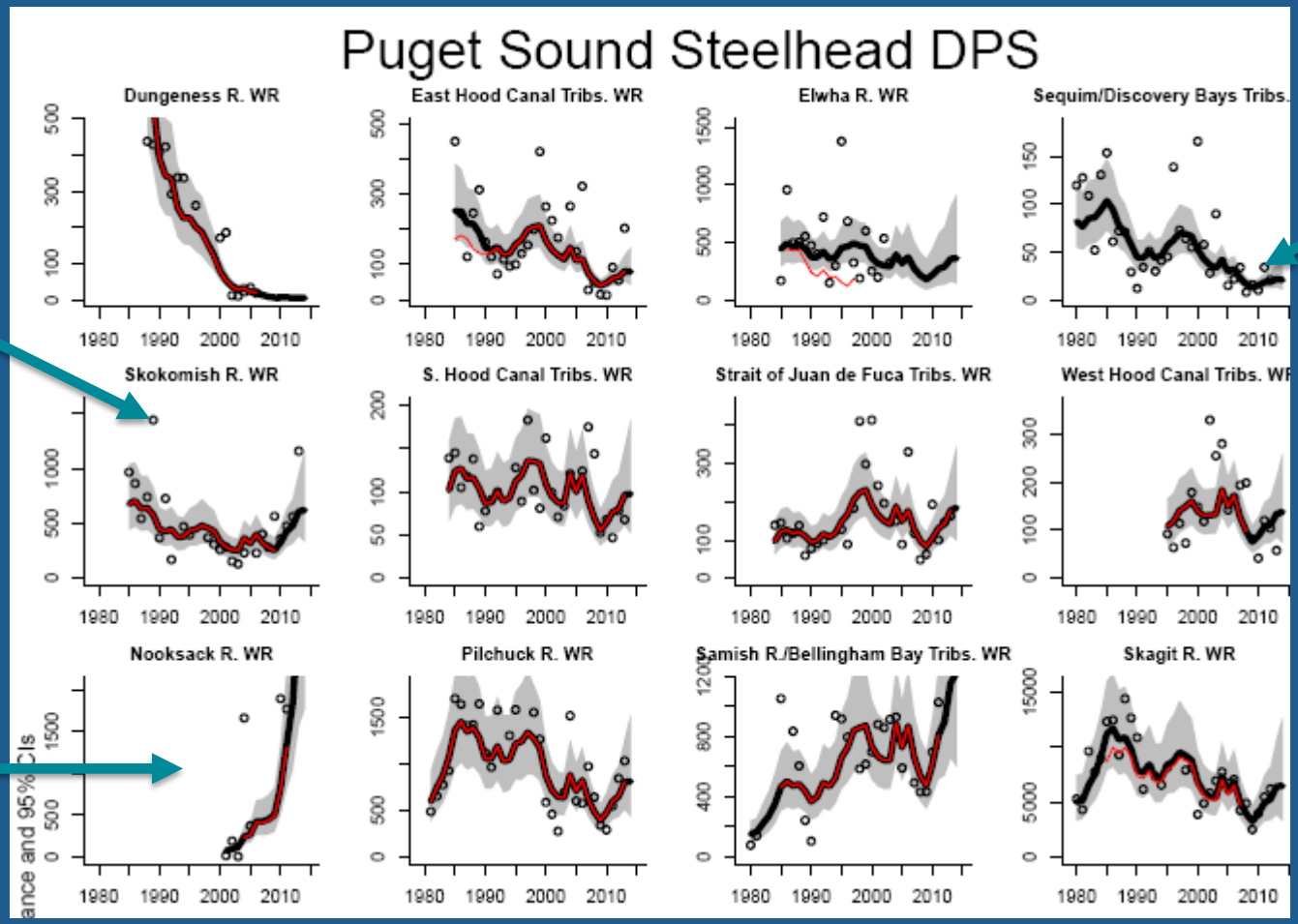
"Common metrics" analysis of trend that can be estimated for all regions



Listed salmon are organized into ‘recovery domains’ and within each domain, population groups are defined



Data and the analysis objective



Objective (black line)

Data (dots)

Different regions (panels)

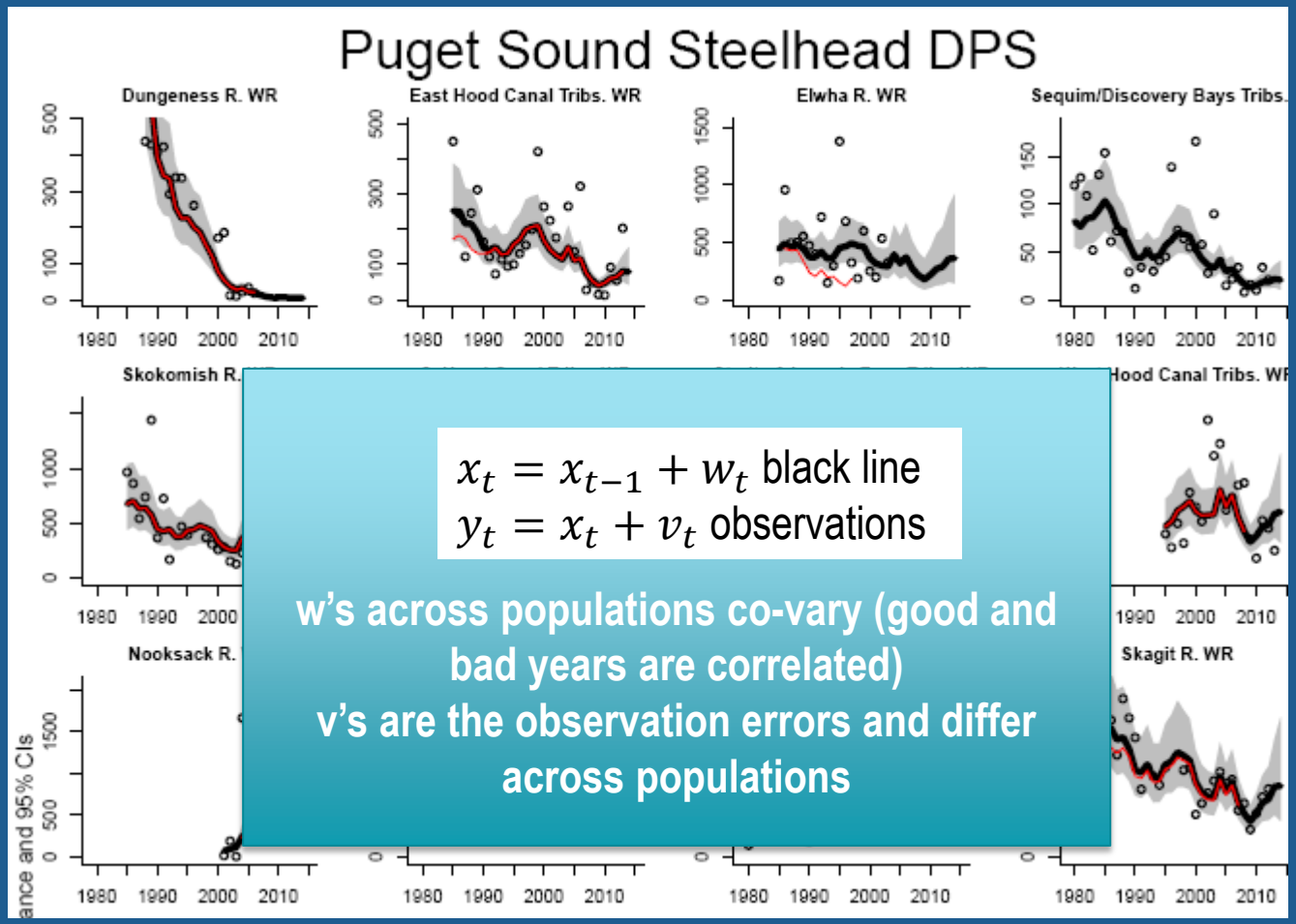
Common approach to estimating the 'trend' (or black line) is 3-year geometric mean

$$(\text{Count 1} \times \text{Count 2} \times \text{Count 3})^{1/3}$$

Problems

- Cannot deal with missing values
- Cannot use information across populations
- Does not use an estimate of measurement error

Alternate approach fits a time-series model



$x_t = x_{t-1} + w_t$ black line
$y_t = x_t + v_t$ observations

w's across populations co-vary (good and bad years are correlated)
v's are the observation errors and differ across populations

Time-series approach

Benefits

- Can deal with missing values
- Uses information across populations to improve estimation
- Estimates measurement error

Output that goes into status assessments

Tables of changes in 5- and 15-year trends

Table 4: 15-year trends (slope) in log wild spawner abundance computed from a linear regression applied to the smoothed wild spawner log abundance estimate versus year. Only populations with at least 4 wild spawner estimates from 1980 to 2014 are shown and with at least 2 data points in the first 5 years and last 5 years of the 15-year period.

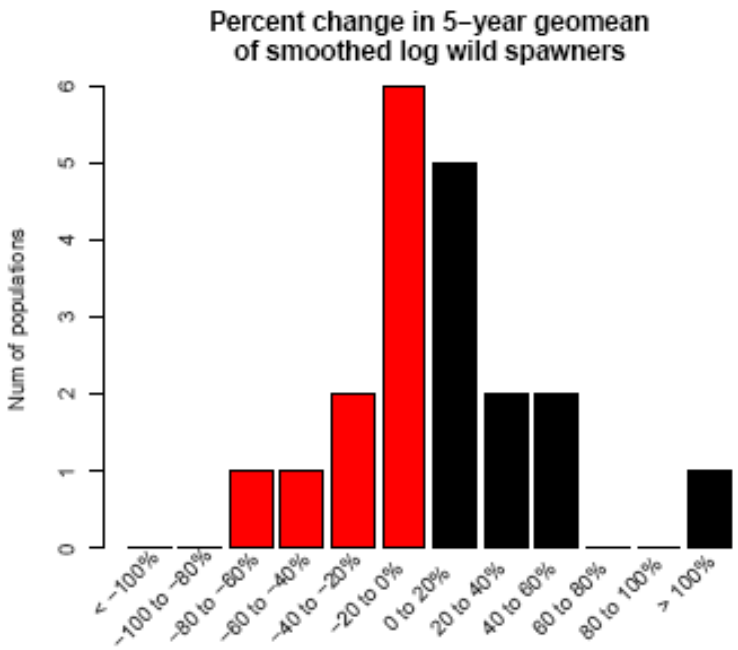
Population	MPG	1990-2005	1999-2014
Dungeness R. WR	Hood Canal/SJF	-0.2 (-0.23, -0.17)	
East Hood Canal Tribs. WR	Hood Canal/SJF	0 (-0.03, 0.02)	-0.08 (-0.12, -0.05)
Elwha R. WR	Hood Canal/SJF		
Skokomish R. WR	Hood Canal/SJF	-0.03 (-0.05, -0.01)	
S. Hood Canal Tribs. WR	Hood Canal/SJF	0.01 (-0.01, 0.03)	-0.02 (-0.05, 0)
Strait of Juan de Fuca Tribs. WR	Hood Canal/SJF	0.04 (0.01, 0.06)	-0.02 (-0.05, 0.01)
West Hood Canal Tribs. WR	Hood Canal/SJF		
Pilchuck R. WR	North Sound	-0.04 (-0.06, -0.01)	-0.02 (-0.05, 0.01)
Samish R./Bellingham Bay Tribs. WR	North Sound	0.04 (0.02, 0.07)	0.02 (-0.01, 0.05)

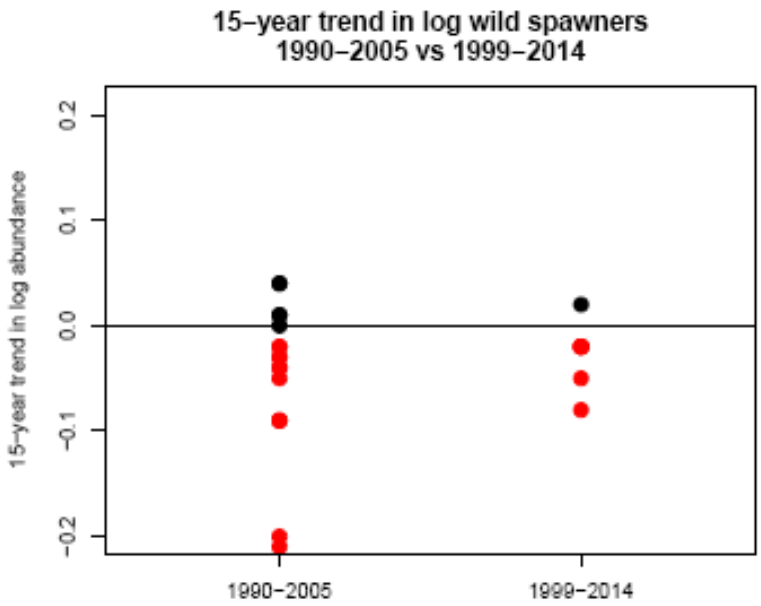
Table 1: 5-year geometric mean of smoothed wild spawner estimate (smoothed total spawners times smoothed fracwild). In parentheses, the 5-year geometric mean of smoothed total spawners (black thick line in graphs) is shown. A row with only values in parentheses indicates that no fraction wild estimates were available for that population. Geometric mean was computed as the product of counts raised to the power 1/5. Percent change between the most recent two 5-year periods is shown on the far right.

Population	MPG	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	% Change
Dungeness R. WR	Hood Canal/SJF	304 (304)	173 (175)	42 (43)	12 (13)	6 (6)	-50 (-54)
East Hood Canal Tribs. WR	Hood Canal/SJF	134 (140)	188 (188)	139 (139)	73 (73)	65 (65)	-11 (-11)
Elwha R. WR	Hood Canal/SJF	218 (377)	157 (467)	121 (329)	96 (261)	108 (293)	12 (12)
Sequim/Discovery Bays Tribs. WR	Hood Canal/SJF	(46)	(65)	(41)	(22)	(19)	(-14)
Skokomish R. WR	Hood Canal/SJF	417 (417)	451 (451)	298 (298)	314 (314)	481 (481)	53 (53)
S. Hood Canal Tribs. WR	Hood Canal/SJF	91 (91)	127 (127)	99 (99)	84 (84)	82 (82)	-2 (-2)
Strait of Juan de Fuca Tribs. WR	Hood Canal/SJF	107 (107)	192 (192)	166 (166)	122 (122)	145 (145)	19 (19)

Output that goes into status assessments

Figures of changes in 5- and 15-year trends





Risk assessments (=forecasting) for listed salmonids

- Linear stock-recruitment function (no density-dependence). R=pS
  - Forecast forward
  - Number of years to hit threshold
  - Probability population hits threshold in x years

- Non-linear stock-recruitment functions
  - Estimate Ricker, Beverton-Holt, Logistic
  - Forecast forward under different by-catch levels
  - Probability population hits threshold in x years

Later this week: Hands-on computer labs

- Trend assessment from multiple sites
- Population risk assessment from count data

Install R
Install the following R packages
    MARSS