WF4113-Fisheries Science

Class 14: Harvest, Gear, Effort, and Yield

Housekeeping

Housekeeping

- Volunteer opportunity
  - Paddlefish: Thursday AM until ~ noon ish
  - Let me know after class if interested

Spatial Predator-Prey Dy-namics in the Serengeti

Dr. John Fryxell
Department of Integrative Biology, University of Guelph

March 1, 2017, 10:00 a.m.

Just what the heck do we do?

1. Missouri River Pallid Sturgeon Recovery
2. Noxubee NWR Paddlefish
3. Use of agriculture plantings to establish fish cover in flood control reservoirs
4. Evaluation of MDWFP statewide fish monitoring protocols
5. Epidemiological modeling of VaH in catfish aquaculture
6. Landscape prioritization of aquatic species conservation efforts

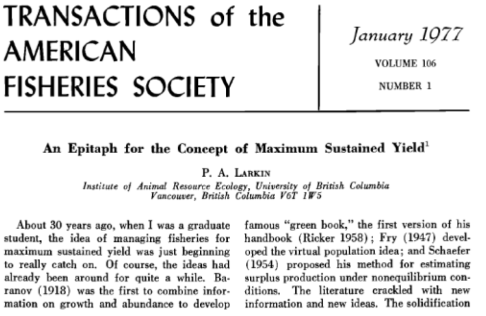
Fisheries icon:

- Don W. Gabelhouse Jr.
- University of Nebraska, Lincoln
- University of Missouri, Columbia
- Kansas Fish and Game Commission
- Chief, Nebraska Games and Parks Commission

Claims to fame

- Structural indices of population
  - 5 cell PSD system
- Slot limits for largemouth bass
- Pond management, balanced systems

Epitaph for MSY



TRANSACTIONS of the AMERICAN FISHERIES SOCIETY

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NUMBER 1

An Epitaph for the Concept of Maximum Sustained Yield[1]

P. A. Larkin

Institute of Animal Resource Ecology, University of British Columbia Vancouver, British Columbia V6T 1W5

About 30 years ago, when I was a graduate student, the idea of managing fisheries for maximum sustained yield was just beginning to really catch on. Of course, the ideas had already been around for quite a while. Baranov (1918) was the first to combine information on growth and abundance to develop famous "green book," the first version of his handbook (Ricker 1958); Fry (1947) developed the virtual population idea; and Schaefer (1954) proposed his method for estimating surplus production under nonequilibrium conditions. The literature crackled with new information and new ideas. The solidification

$F_{0.1}$

The use of $F_{0.1}$ has emerged as a useful "rule of thumb" for managing fisheries, but according to Hilborn and Walters (1992) this is an arbitrary, ad hoc strategy with no theoretical basis.

How do we figure out $F_{0.1}$

1. Find slope at origin
2. Plot line with 10% of this slope
3. Find tangent of curve at this slope

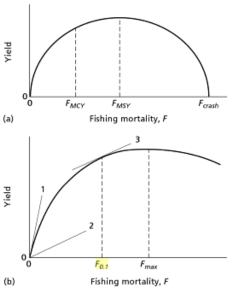
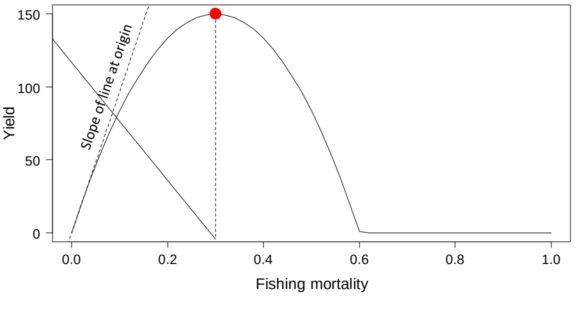
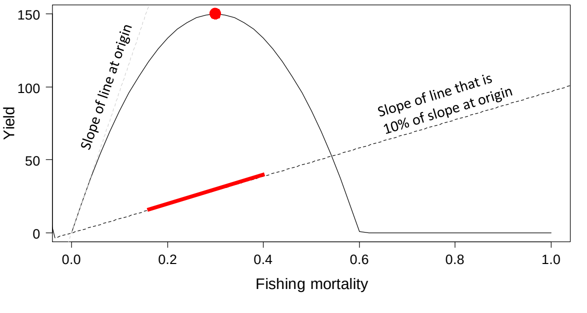


Fig. 7.20 Biological reference points. (a) Surplus production model; (b) yield-per-recruit model. $F_{0.1}$ is found by following the numbered steps indicated: (1) find slope at origin; (2) plot line with 10% of this slope; (3) find tangent to curve at this slope.

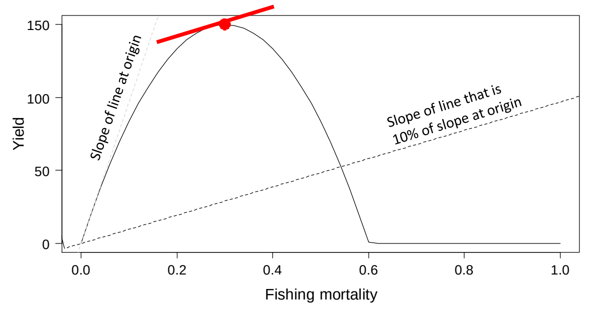
Slope at origin



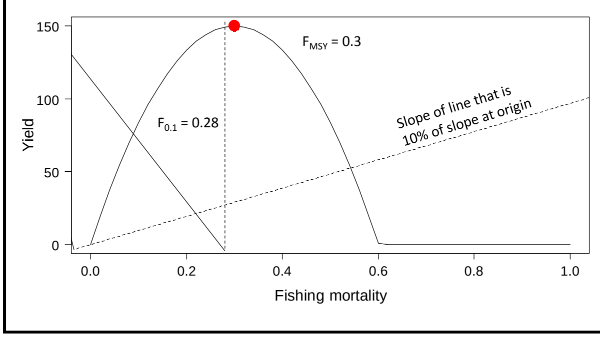
10% of slope at origin



10% of slope at origin



$F_{0.1}$



Continuous harvest

Suppose harvest does not occur continuously…

Is this realistic?

Examples?

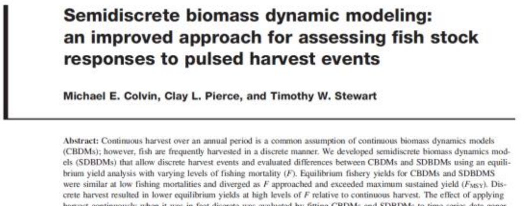
Continuous harvest

Lake	County	Length Limit	Creel Limit
Enid Lake	Yalobusha, Lafayette, Panola	12" MLL	20
Grenada Lake	Grenada, Calhoun, Yalobusha	12" MLL	20
Horn Lake	Desoto Co.	10" MLL	30
Lake Okhissa	Franklin	10"MLL	10
Lake Washington	Washington	10" MLL	30 (5 under 10")
Moon Lake (includes part east of Hwy 1)	Coahoma	10" MLL	30 (5 under 10")
Pickwick & Tenn-Tom Waterway	Hwy 25 in Divide Section to Aliceville Lock & Dam	9" MLL	30
Sardis Lake	Lafayette, Marshall, Panola	11" MLL	15
Spillways of Arkabutla	To Prichard Road Bridge		20
Enid	To I-55		20
Grenada	To Hwy 51		20
Sardis & Barrow Lake	To Spaulding Creek		20

http://www.mdwfp.com/media/218652/creel_limits_pt._3_chaper_1.pdf

- Exponential→ Graham Schaefer (added K)→ Pella-Tomilson & Fox (relaxed linear assumption of DD).

Continuous harvest?



Semidiscrete biomass dynamic modeling: an improved approach for assessing fish stock responses to pulsed harvest events

Michael E. Colvin, Clay L. Pierce, and Timothy W. Stewart

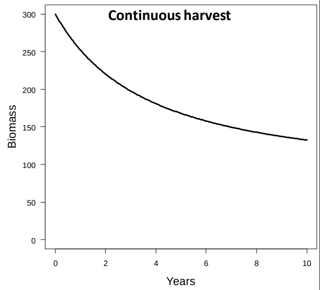
Abstract: Continuous harvest over an annual period is a common assumption of continuous biomass dynamics models (CBDMs); however, fish are frequently harvested in a discrete manner. We developed semidiscrete biomass dynamics models (SDBDMs) that allow discrete harvest events and evaluated differences between CBDMs and SDBDMs using an equilibrium yield analysis with varying levels of fishing mortality (F). Equilibrium fishery yields for CBDMs and SDBDMS were similar at low fishing mortalities and diverged as F approached and exceeded maximum sustained yield (F_{MSY}). Discrete harvest resulted in lower equilibrium yields at high levels of F relative to continuous harvest. The effect of applying

Colvin, M.E., Pierce, C.L., Stewart, T.W., 2012. Semidiscrete biomass dynamic modeling: an improved approach for assessing fish stock responses to pulsed harvest events. Canadian Journal of Fisheries and Aquatic Sciences 69, 1710-1721.

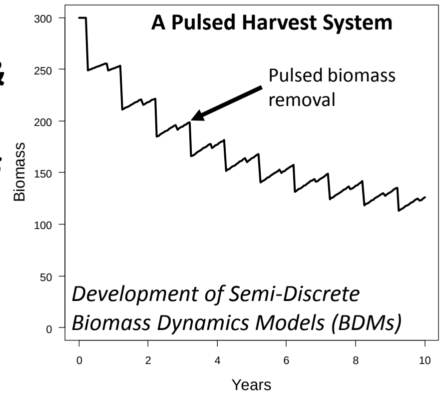
Traditional biomass models

- Assumes harvest occurs continuously
- Biomass models guide stock management
- Pulsed harvest?

Does assuming continuous harvest make a difference?



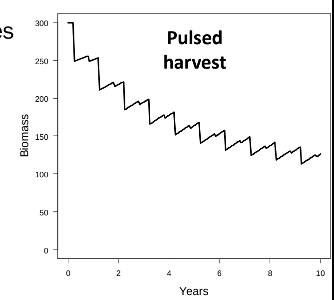
Pulsed harvest & biomass dynamics

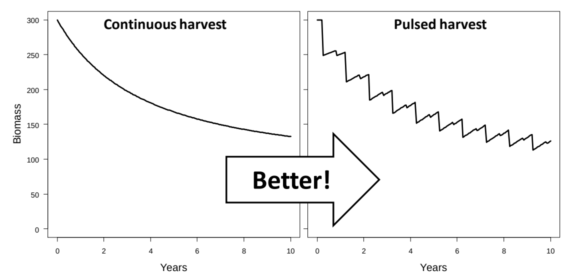


Development of Semi-Discrete Biomass Dynamics Models (BDMs)

Semi-discrete models

- Hybrid class of models that allow pulsed events in continuous time
- Continuous processes
  - intrinsic growth rate
- Pulsed harvest

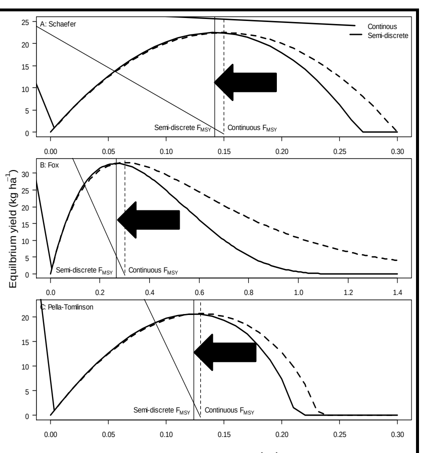




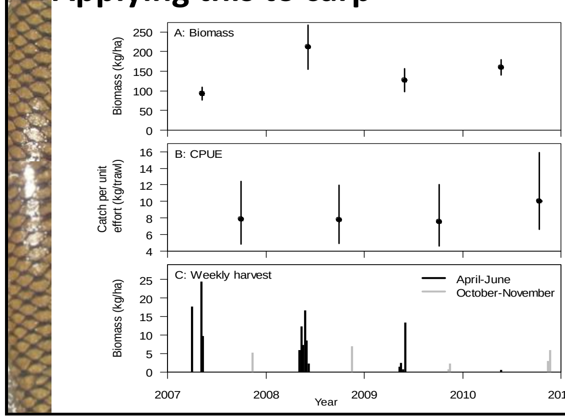
Can biomass dynamics models be improved by accounting for pulsed harvests? YES

Equilibrium yields

Assuming continuous harvest over estimates MSY!



Applying this to carp



Carp biomass dynamics model

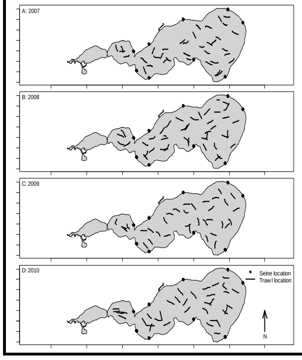
$$\left.\begin{aligned}\frac{dB(t)}{dt} &= rB(t), && t \neq \tau_k\\ B(\tau_k^+) &= B(\tau_k) - C(\tau_k), && t = \tau_k\end{aligned}\right\}$$

$$\bar{I}(t) = qB(t)$$

Fit to data by maximum likelihood to estimate *r* & *q*, given B, I, and C

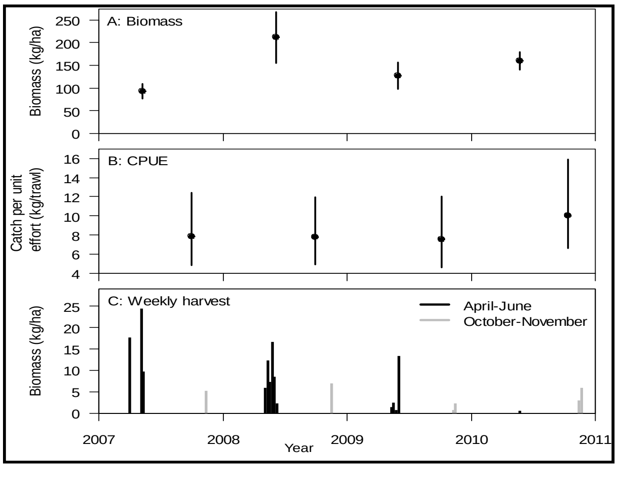
Estimating standing biomass

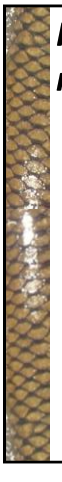
Trawling to index biomass (CPUE)



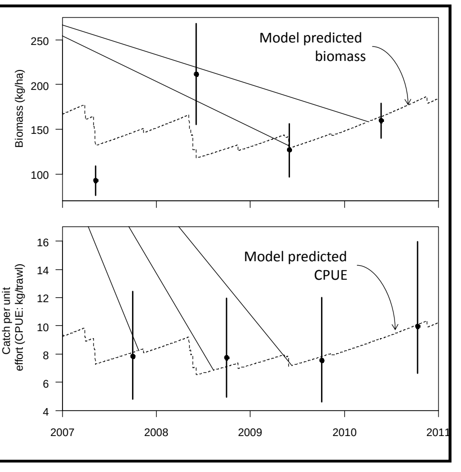
Tracking carp biomass harvested

When & how much biomass is harvested





Fitted model



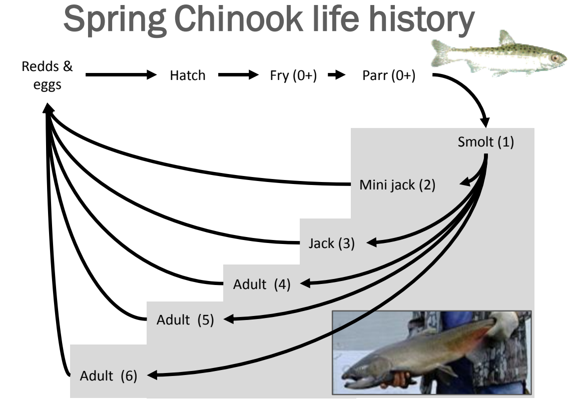
The big picture

- Global fisheries estimated to be worth $91.2 billion according to United Nations
  - 82 billion for saltwater
  - 10 billion for freshwater
  - In the round…
- Managing fisheries is serious economic business
- Lots of stakeholders…

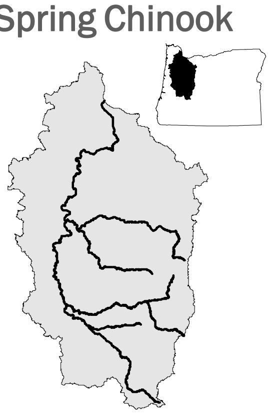
Not just about yield

- MSY is tough to attain
- Really not interested in catching fish for the sake of catching fish
- Interested in $$$
- Linking yield to money
- Lets look at Spring Chinook salmon

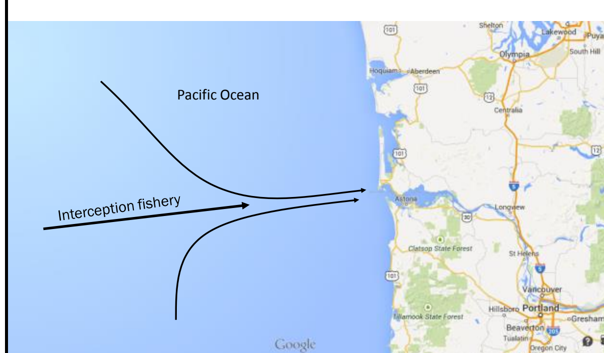
Spring Chinook life history



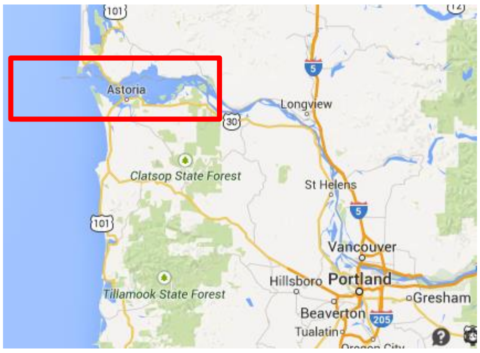
Willamette Basin Spring Chinook



Fish return ~ February



Commercial fisheries & profits



Spring Chinook Salmon

- Average 25 pounds
- 16 to 25 USD per pound **in the round**
- 400 to 625 USD per fish!
  - 1000 fish= 40 to 62.5K USD
  - 10,000 fish = 400 to 625K USD

Why so expensive?

- Life history
- Return to fresh water early!

Biomass & harvest dynamics

$$\frac{dBiomass}{dt} = r \cdot \frac{K - Biomass_t}{K} - F \cdot Biomass_t$$

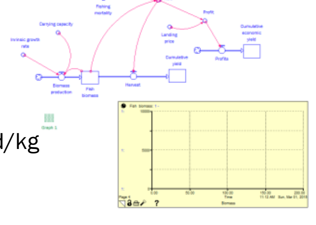
$$\frac{dYield_{biomass}}{dt} = F \cdot Biomass$$

$$\frac{dYield_{economic}}{dt} = F \cdot Biomass \cdot Landing\ price$$

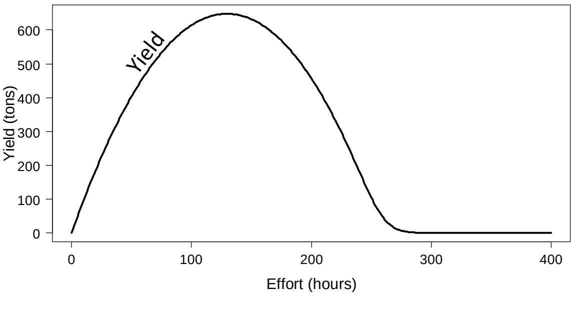
MSY & economic yield

Link yields to profits

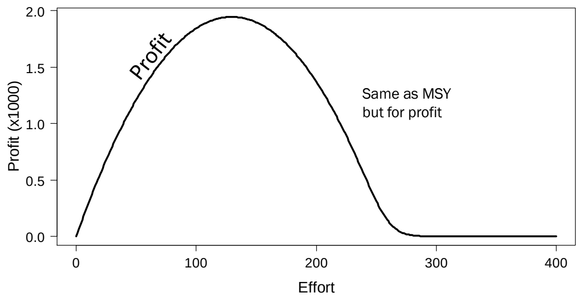
- Graham Schaefer
  - r=0.3
  - K=10,000
  - B_0=9,000
  - Landing price=4 usd/kg



Maximum sustained yield



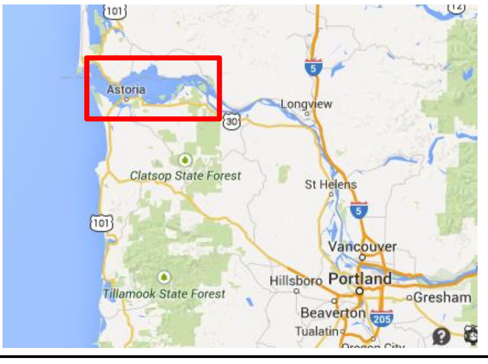
Maximum economic yield



No free lunch

- Harvest of fish requires effort!
- Effort cost something… money, person hours

Fisheries & effort



Incorporating effort

Effort

Gear	Effort (days)	Total catch	Catch per effort
Gill nets	55	6600	120

Need to link effort and yield
Example if I fish for 4 hours how much fish will I catch?

Catchability

$$Catch = effort \cdot catchability \cdot Biomass$$
$$6600 = 55 \cdot catchability \cdot Biomass$$

Just need to know biomass….
Or catchability

Estimating biomass & catchability

- Mark recapture
- Calibrated fishery independent surveys
- Catchability is much more difficult
  - Function of biomass
  - Need catch, biomass, and effort

Biomass & harvest dynamics

$$\frac{dBiomass}{dt} = r \cdot \frac{K - Biomass_t}{K} - effort \cdot catchability \cdot Biomass_t$$

$$\frac{dYield_{biomass}}{dt} = effort \cdot catchability \cdot Biomass_t$$

$$\frac{dYield_{economic}}{dt} = effort \cdot catchability \cdot Biomass_t \cdot Landing\ price$$