WF4313/6613-Fisheries Management

Class 14– Yield Management & Management Case Study

Announcements

Class Topics

Yield and biomass management

Management case study

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.

Continuous harvest

Suppose harvest does not occur continuously…

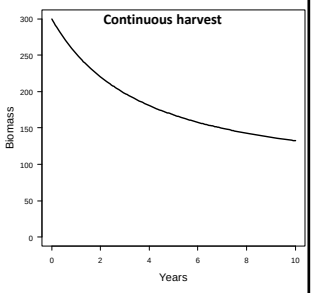
Is this realistic?

Examples?

Traditional biomass models

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

Does assuming continuous harvest make a difference?



Continuous harvest?

Finfish

Mississippi Red Snapper 2015

All vessels (private and for-hire) landing Red Snapper in Mississippi must use the Tails n' Scales electronic reporting system regardless of harvest area (federal waters, Mississippi state waters, adjacent states' waters, etc.) There are no exemptions. Mississippi Department of Marine Resources (MDMR) requires one report per trip per vessel.

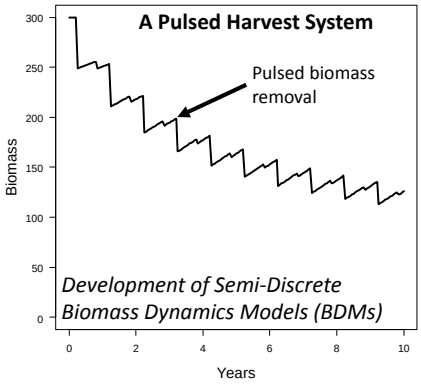
The federal Red Snapper season begins on Monday, June 1st and ends on Wednesday, June 10th for recreational anglers. The Mississippi Red Snapper season begins on Thursday July 16th and ends on Saturday October 31st. The Commission on Marine Resources gave the MDMR Executive Director, Jamie Miller, the authority to establish supplemental state seasons.

During the 2015 season a trip authorization number must be obtained by a representative of each vessel prior to recreationally fishing for Red Snapper. Trip authorization numbers are only valid for 24 hours and must be closed out each time before a new trip number will be issued.

Registering, obtaining trip authorization numbers, and reporting harvest are easy and can be done using any of the methods listed below.

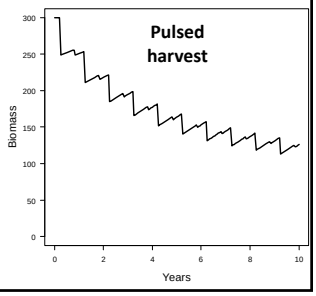
Free Downloadable App: **Tails n' Scales**

Pulsed harvest & biomass dynamics

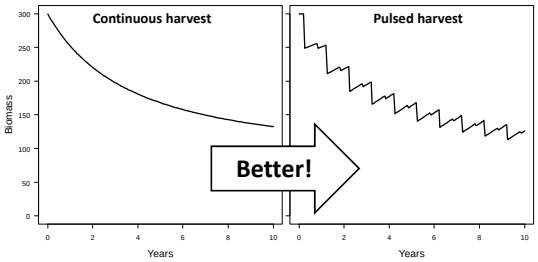


Semi-discrete models

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



MANAGING COMMON CARP BIOMASS



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

North American Journal of Fisheries Management 32:1251–1264, 2012
© American Fisheries Society 2012
ISSN: 0275-5947 print / 1548-8675 online
DOI: 10.1080/02755947.2012.728175

ARTICLE

Strategies to Control a Common Carp Population by Pulsed Commercial Harvest

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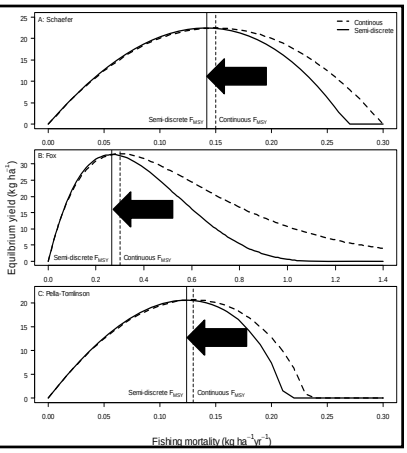
Abstract
Commercial fisheries are commonly used to manage nuisance fishes in freshwater systems, but such efforts are often unsuccessful. Strategies for successfully controlling a nuisance population of common carp *Cyprinus carpio* by pulsed commercial harvest were evaluated with a combination of (1) field sampling, (2) population estimation and CPUE indexing, and (3) simulation using an exponential semidiscrete biomass dynamics model (SDBDM). The range of annual fishing mortalities (F) that resulted in successful control ($F = 0.244–0.265$) was narrow. Common carp biomass dynamics were sensitive to unintentional underharvest due to high rates of surplus production and a biomass doubling time of 2.7 years. Simulations indicated that biomanipulation never achieved successful control unless supplemental fishing mortality was imposed. Harvest of a majority of annual production was required to achieve successful control, as indicated by the ecotrophic coefficient (EC). Readily available biomass data and tools such as SDBDMs and ECs can be used in an adaptive management framework to successfully control common carp and other nuisance fishes by pulsed commercial fishing.

Equilibrium sustained yields

Assuming continuous harvest over estimates MSY!

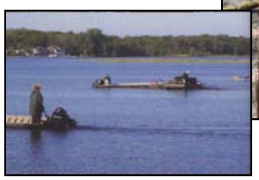


Carp effects on water quality

Carp effects on water quality

Managing carp biomass

- Pulsed intense removals over a short period
  - Large removals
  - Short duration
  - Spring and fall



Water quality: internal processes

Water column

Sediments **Nutrients**

Lake bottom

Mangement

- Objectives: 100 kg carp per hectare
- Decision alternatives
  - Commercial fishing
  - Biomanipulation (removal of 75% of biomass)
  - Biomanipulation (removal of biomass to 100 kg/ha)

Clear Lake is valuable

- Averaged **432,312** visitors annually
- Visitors spend an average **$43.36 million** annually
  - Supports **529** jobs
- **$1-3 million USD** recreational fishery

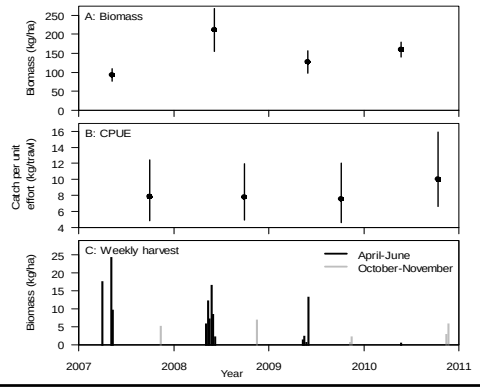
Carp biomass dynamics model

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

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

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

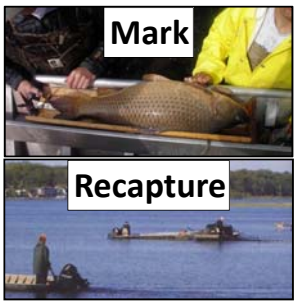
Applying this to carp

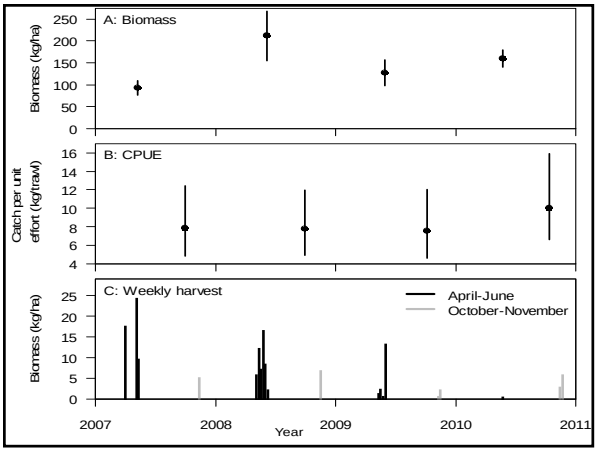


Tracking carp biomass harvested

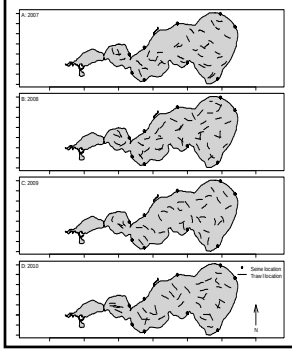
When & how much biomass is harvested

Estimating standing biomass

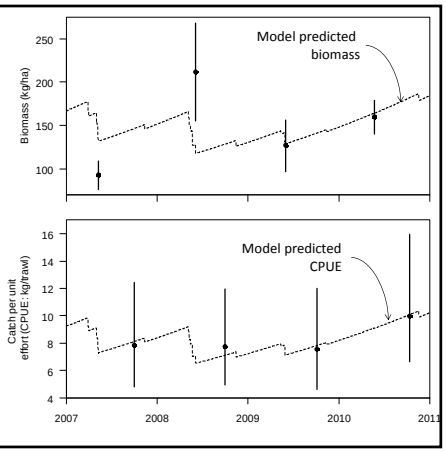




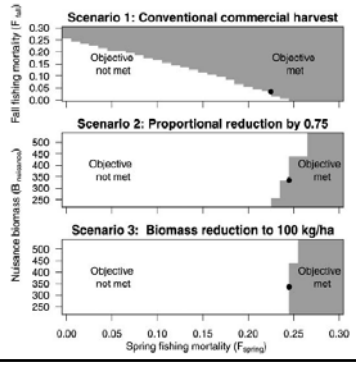
Trawling to index biomass (CPUE)



Fitted model



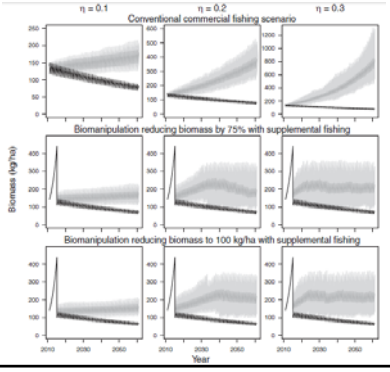
Meeting management objectives



In a nutshell-preventing or minimizing growth overfishing!

MANAGING YIELD IN AGE STRUCTURED POPULATIONS

Partial Controllability

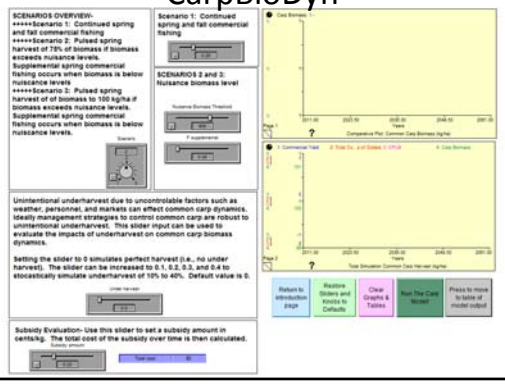


What is growth overfishing?

Harvest fish before they have time to grow

Example:

CarpBioDyn



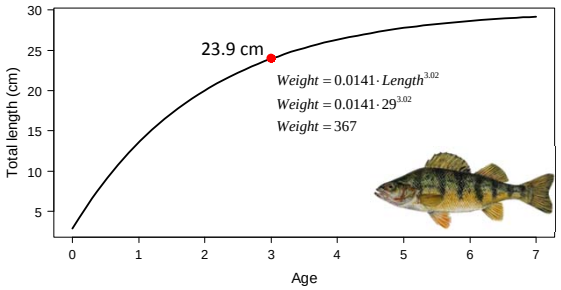
Growth process in fish

The assimilation of food as biomass (i.e., tissue). Primarily refers to somatic tissue but also includes gonad tissue.

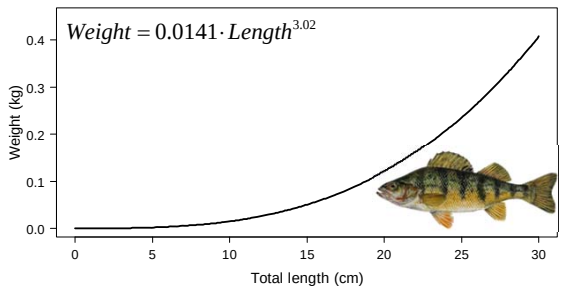
- Fish adding **weight** over **time**
  1. **Relate time (age) to length**
  2. **Relate length to weight**

Age-length

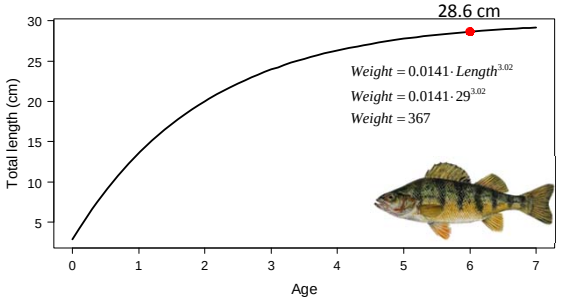
Weight for an age-3 fish



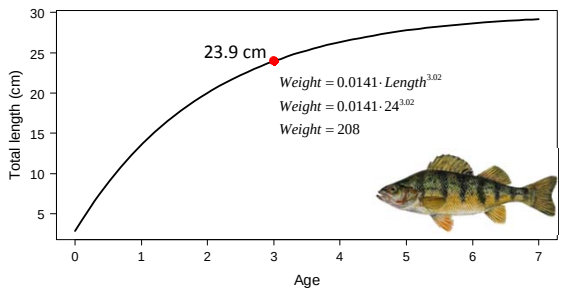
Length-weight



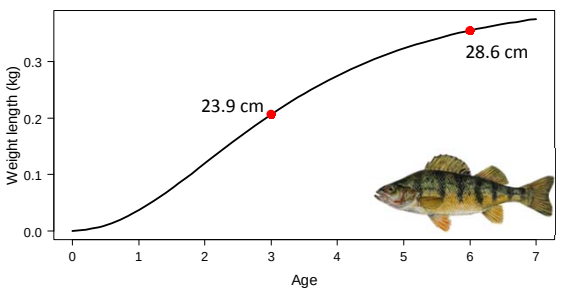
Weight for an age-6 fish



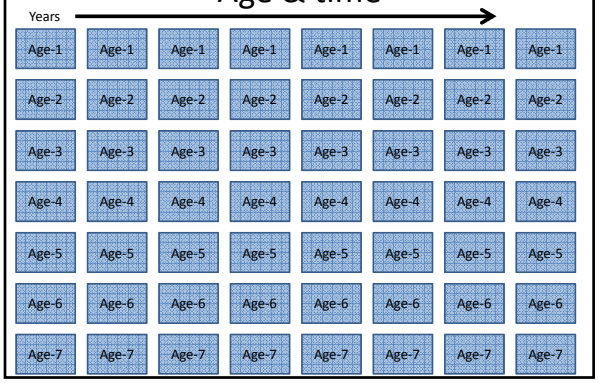
Weight for an age-3 fish



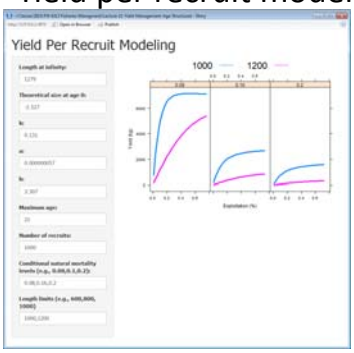
Age-weight



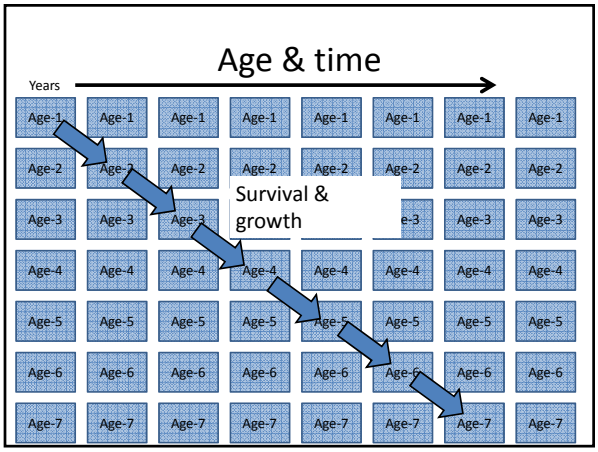
Age & time



Yield per recruit model!



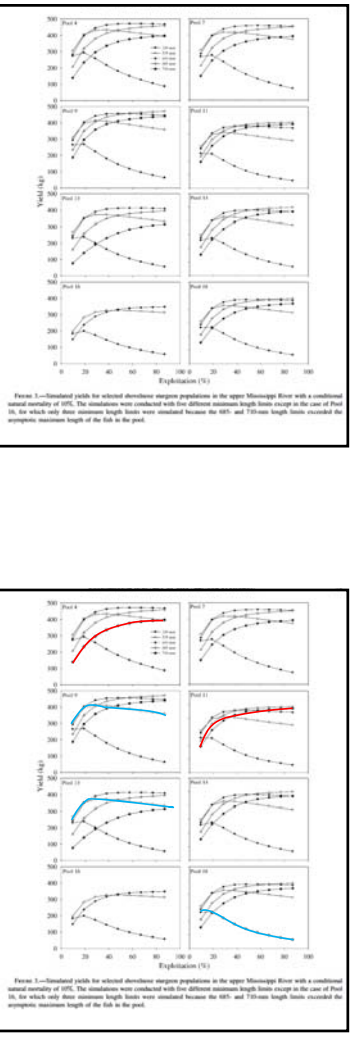
Age & time



Diagnosing growth overfishing

Growth overfishing

No growth overfishing



Trade off

1. Harvesting a lot of smaller fish
2. Harvesting fewer, but larger fish

How do we evaluate whether growth overfishing is occurring?

Diagnosing growth overfishing

Growth overfishing

No growth overfishing