WF4313/6613-Fisheries Management

Class 6– Biomass dynamics, Mismanagement, & Age Structure

Announcements

In the news

A fishery

Value

Fish have social & economic value

Fish

Fish need habitat

Fish can influence habitat

Habitat

A fishery

Value

Fish have social & economic value

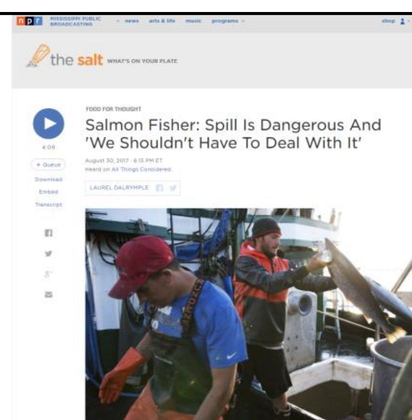
Fish

Fish need habitat

Fish can influence habitat

~~Habitat~~

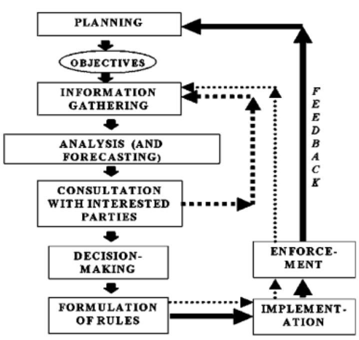
Aquaculture…

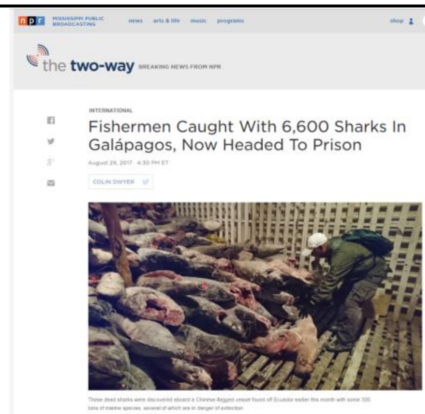


What's the big deal?

What's the big deal?

Fisheries Management Conceptually





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the two-way BREAKING NEWS FROM NPR

INTERNATIONAL

Fishermen Caught With 6,600 Sharks In Galápagos, Now Headed To Prison

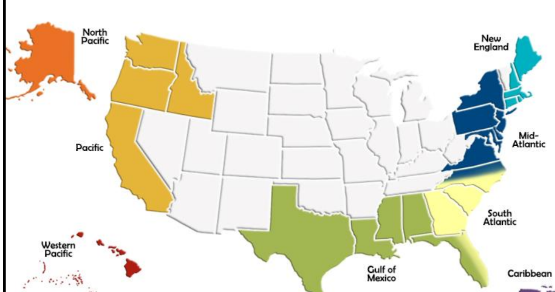
August 29, 2017 · 4:30 PM ET

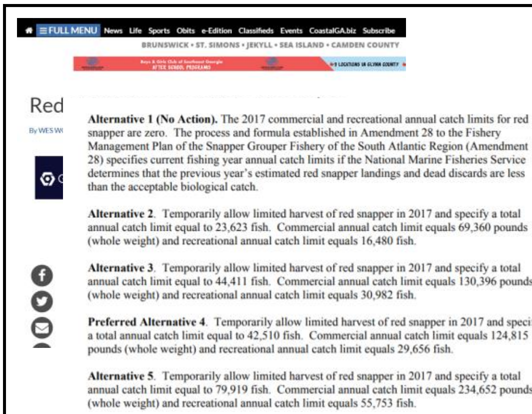
COLIN DWYER

These dead sharks were discovered aboard a Chinese-flagged vessel found off Ecuador earlier this month with some 300 tons of marine species, several of which are in danger of extinction.

Galapagos National Park via AP

Fisheries Management Councils





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Red

Alternative 1 (No Action). The 2017 commercial and recreational annual catch limits for red snapper are zero. The process and formula established in Amendment 28 to the Fishery Management Plan of the Snapper Grouper Fishery of the South Atlantic Region (Amendment 28) specifies current fishing year annual catch limits if the National Marine Fisheries Service determines that the previous year's estimated red snapper landings and dead discards are less than the acceptable biological catch.

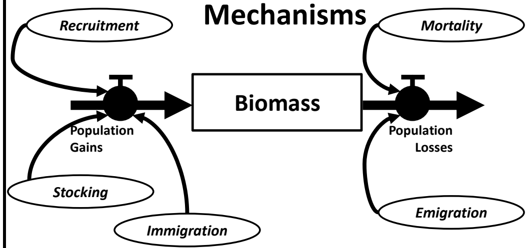
Alternative 2. Temporarily allow limited harvest of red snapper in 2017 and specify a total annual catch limit equal to 23,623 fish. Commercial annual catch limit equals 69,360 pounds (whole weight) and recreational annual catch limit equals 16,480 fish.

Alternative 3. Temporarily allow limited harvest of red snapper in 2017 and specify a total annual catch limit equal to 44,411 fish. Commercial annual catch limit equals 130,396 pounds (whole weight) and recreational annual catch limit equals 30,982 fish.

Preferred Alternative 4. Temporarily allow limited harvest of red snapper in 2017 and specify a total annual catch limit equal to 42,510 fish. Commercial annual catch limit equals 124,815 pounds (whole weight) and recreational annual catch limit equals 29,656 fish.

Alternative 5. Temporarily allow limited harvest of red snapper in 2017 and specify a total annual catch limit equal to 79,919 fish. Commercial annual catch limit equals 234,652 pounds (whole weight) and recreational annual catch limit equals 55,753 fish.

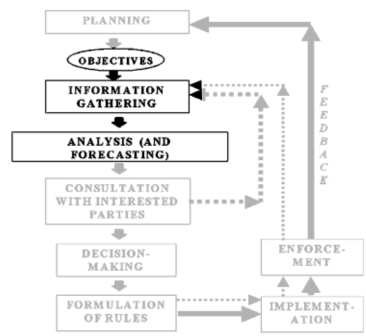
Fish dynamics: States, Processes, & Mechanisms



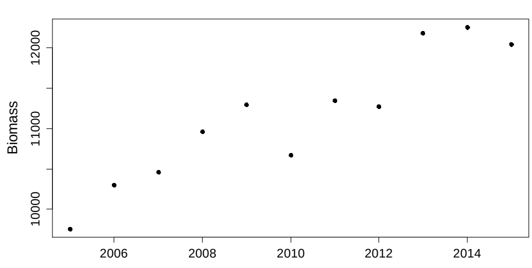
$$\frac{dAbundance}{dt} = (recruitment + stocking + immigration) - (mortality + emigration)$$

WFA 4313/6613
Why do we talk about biomass all the time?

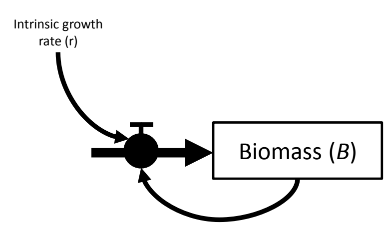
Fisheries Management Conceptually



Some biomass dynamics

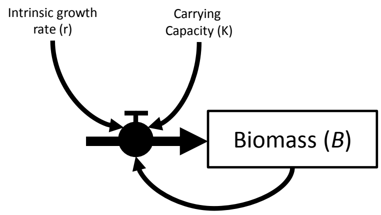


Exponential population model



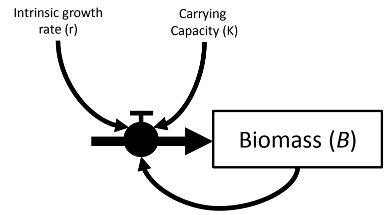
$$\frac{dB}{dt} = r \cdot B$$

Graham-Schaefer model



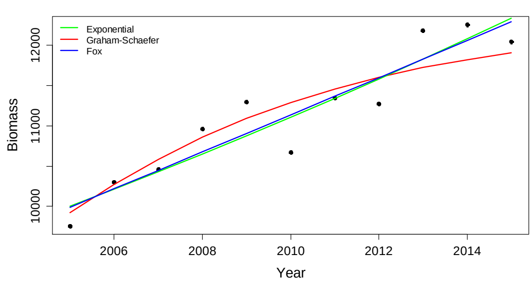
$$\frac{dB}{dt} = r \cdot B \cdot \frac{K - B}{K}$$

Fox model



$$\frac{dB}{dt} = r \cdot B \cdot \left(1 - \log_e \frac{B}{K}\right)$$

Fitting models to the data…



Management:

$$\frac{dB}{dt} = r \cdot B - F \cdot B$$

$$\frac{dB}{dt} = r \cdot B \cdot \frac{K - B}{K} - F \cdot B$$

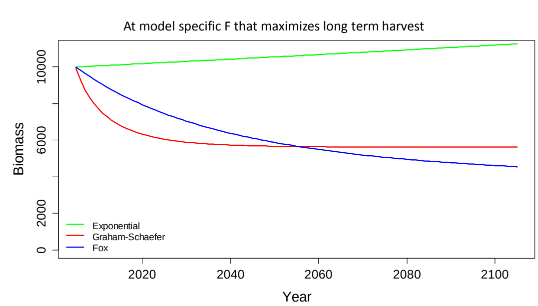
$$\frac{dB}{dt} = r \cdot B \cdot \left(1 - \log_e \frac{B}{K}\right) - F \cdot B$$

What is the best *F*?

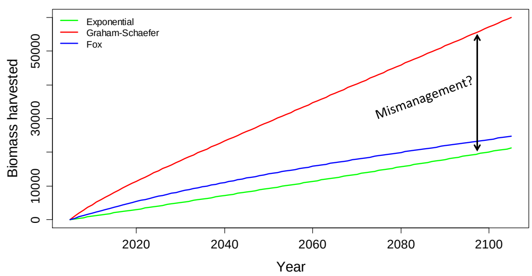
- Maximizes long term harvest
- Use fitted models to forecast
- Evaluate *F* for 0 to 0.5 by values of 0.02

	F	gs	exp	fox
[1,]	0.00	0.00	0.00	0.00
[2,]	0.02	21779.79	21224.10	21646.35
[3,]	0.04	38577.48	18080.53	24713.71
[4,]	0.06	50464.39	15164.34	22688.42
[5,]	0.08	57546.80	13571.16	19928.11
[6,]	0.10	59994.16	12685.12	17609.71
[7,]	0.12	58101.77	12144.02	15893.78
[8,]	0.14	52437.50	11783.38	14672.49
[9,]	0.16	44146.05	11526.45	13805.45
[10,]	0.18	35243.40	11334.22	13180.18
[11,]	0.20	27959.85	11184.99	12718.09
[12,]	0.22	23121.18	11065.78	12367.03
[13,]	0.24	20132.50	10968.37	12092.99
[14,]	0.26	18218.05	10887.27	11873.68
[15,]	0.28	16903.07	10818.70	11694.29

Forecasted biomass dynamics



Forecasted biomass harvested



Key point

- The optimal management decision depended on the model, was not the same!
- Structural uncertainty: we do not know with certainty the model governing biomass dynamics
- Working off of one model, mathematical or in your head, can lead to mismanagement!

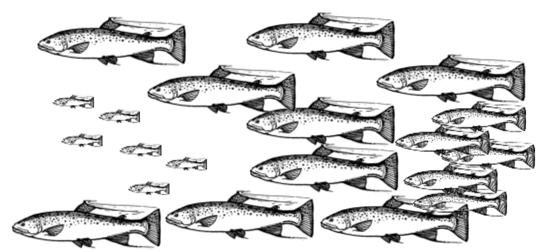
Commercial versus Recreational

Value: Biomass

Value: Size

A Population

Unstructured or structured?



$$Biomass = \sum Abundance \cdot Weight$$

Or

$$Biomass = \sum Abundance_{age} \cdot Weight_{age}$$

Biomass is a function of number of fish and the size of those fish which varies by age

Thinking in terms of fish year class

Where,
N_{t+dt} = number alive at time t
N_t = number alive at time t
Z = instantaneous total mortality rate
dt = time units

$$\frac{dN}{dt} = -Z \cdot N$$

$$\frac{N_{t+dt} - N_t}{dt} = -Z \cdot N_t$$

$$N_{t+dt} - N_t = -Z \cdot N_t \cdot dt$$

$$N_{t+dt} = N_t + (-Z \cdot N_t \cdot dt)$$

Mortality types

Total Mortality (*Z*) is comprised of:

- Natural (*M*)
  1. Predation
  2. Disease, contaminants, toxicants
  3. Senescence
- Fishing (*F*)

Total mortality (*Z*) is *M*+*F*

Cohort: definition

1. In a stock, a group of fish generated during the same spawning season and born during the same time period;
2. In cold and temperate areas, where fish are long-lived, a cohort corresponds usually to fish born during the same year (a year class). For instance, the 1987 cohort would refer to fish that are age 0 in 1987, age 1 in 1988, and so on. In the tropics, where fish tend to be short lived, cohorts may refer to shorter time intervals (e.g. spring cohort, autumn cohort, monthly cohorts).

Source: https://www.st.nmfs.noaa.gov/st4/documents/FishGlossary.pdf

Year Class: definition

Fish in a stock born in the same year. For example, the 1987 year class of cod includes all cod born in 1987. This year class would be age 1 in 1988, age 2 in 1989, and so on. Occasionally, a stock produces a very small or very large year class that can be pivotal in determining stock abundance in later years.

Source: https://www.st.nmfs.noaa.gov/st4/documents/FishGlossary.pdf

Year class dynamics

$$Z = 0.25$$
$$A = 1 - e^{-Z}$$
$$A = 1 - e^{-0.25}$$
$$A = 0.22$$

Longevity ~ 10 years

Year	Abundance
2015	10000
2016	
2017	
2018	
2019	
2020	
2021	
2022	
2023	
2024	
2025	

Year class dynamics

Year	Abundance
2015	10000
2016	10000-2200
2017	
2018	
2019	
2020	
2021	
2022	
2023	
2024	
2025	

Year class dynamics

Year	Abundance
2015	10000
2016	7800
2017	7800-1716
2018	
2019	
2020	
2021	
2022	
2023	
2024	
2025	

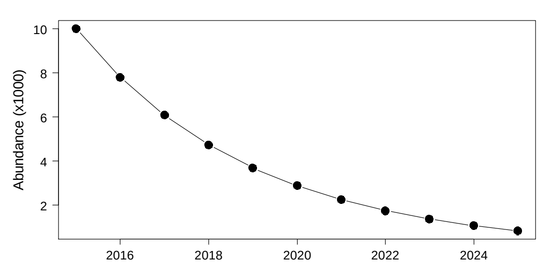
Year class dynamics

Year	Abundance
2015	10000
2016	7800
2017	6084
2018	6084-1338
2019	
2020	
2021	
2022	
2023	
2024	
2025	

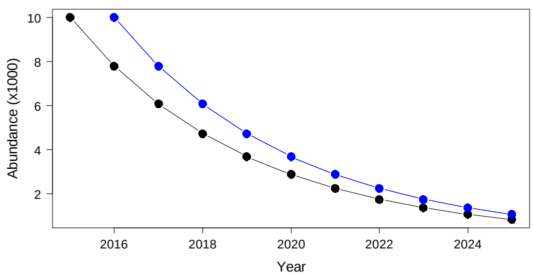
Year class dynamics

Year	Abundance
2015	10000
2016	7800
2017	6084
2018	4745
2019	3701
2020	2887
2021	2252
2022	1757
2023	1370
2024	1069
2025	833

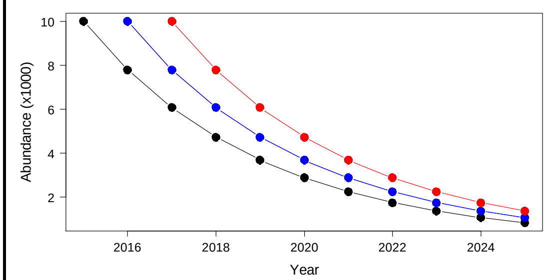
Year class dynamics



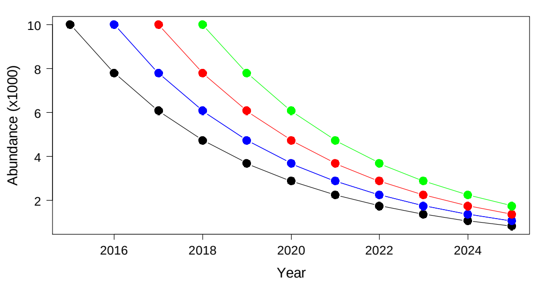
Multiple year-classes



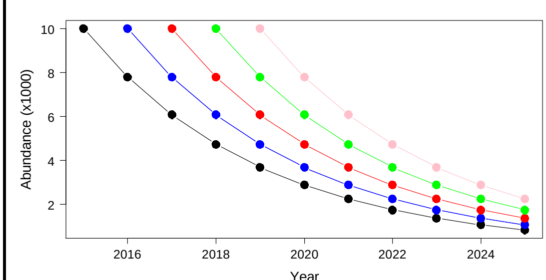
Multiple year-classes



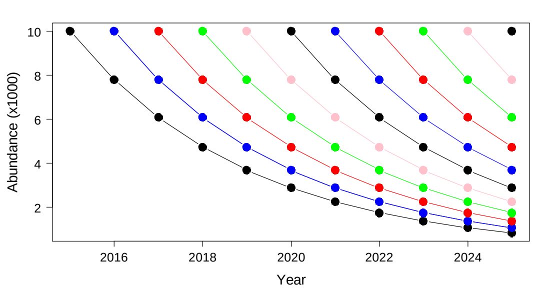
Multiple year-classes



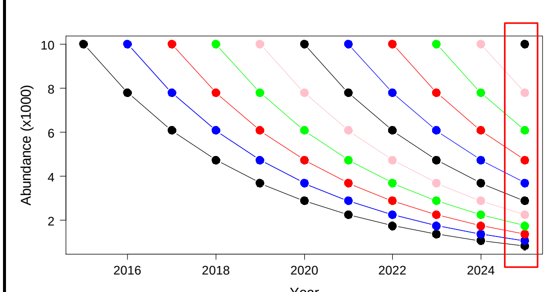
Multiple year-classes



At any given year

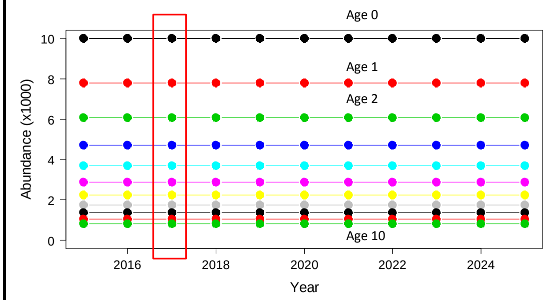


At any given year

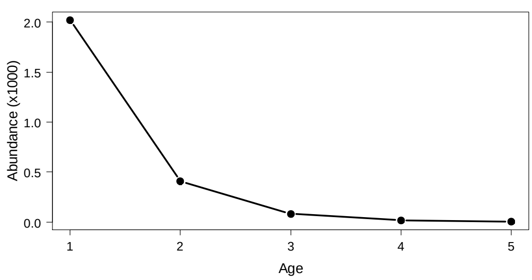


Stable age distribution

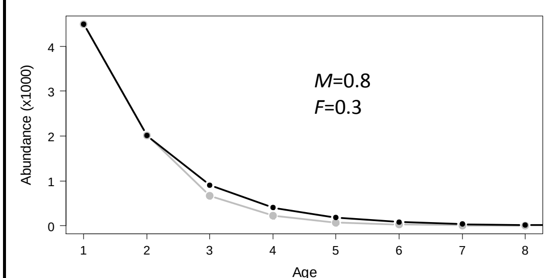
Equilibrium age distribution



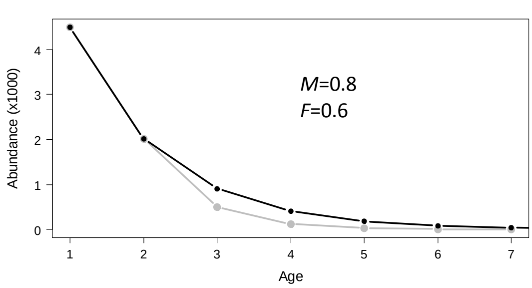
Fishing mortality depends on size



Effect of fishing



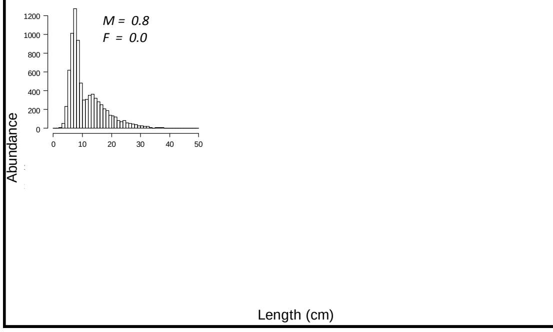
Effect of fishing



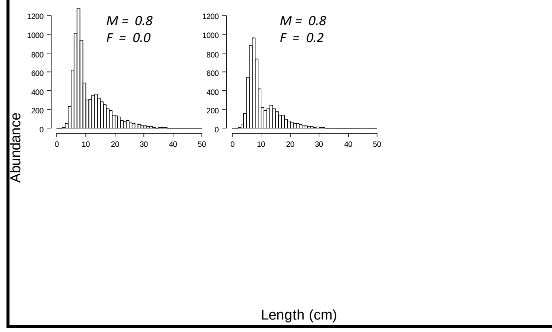
Size structure

Lets look at a population of Black Crappie with a natural mortality rate (*M*) of 0.8 for the following levels of fishing mortalities: 0.0, 0.2, and 0.4, 0.6, 0.8

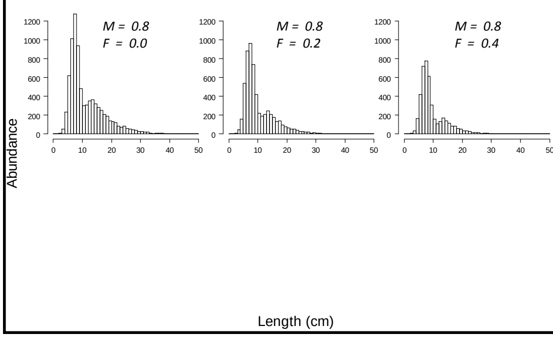
Size structure



Size structure



Size structure



Size structure