Fisheries Management Overview

Great Lakes Fisheries Leadership Institute

By

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Module Objectives

- Provide a brief overview of fisheries management
- Describe why a fishery is a renewable resource?
- Describe the tools of fisheries management
- Examine why carrying capacity varies from lake to lake

Unit One

What is Fishery Management?

Definitions

- **Fisheries Science**
  - The scientific study of the use of the living resources of the waters. Part of fisheries science deals with the biological, physical, and chemical aspects of organic production; part with the distribution and abundance of resources; part with the effects of fishing. It is an applied science which includes study directed at basic understanding as well study designed to provide a background for decisions.

Definitions

- **Fisheries Management**
  - The art and science of producing sustained annual crops of wild fish for recreational and commercial uses.
  - The manipulation of fish populations or their environment in an orderly fashion that is designed to meet a pre-determined goal.

Do you see a difference between the definitions for fisheries science and fisheries management?

Goals of Fishery Management:

According to our definition, we must decide on a goal.

- Maximum Sustainable Yield (MSY). In theory there is a maximum yield (catch) from every fishery that can be sustained year after year.

  Problems:

  - Single species goal didn't take into account species interactions
  - Harvest at MSY is usually economically inefficient
  - May lead to catastrophe in stock if there is a year class failure

Goals of Fishery Management:

According to our definition, we must decide on a goal.

- Optimum Sustainable Yield (OSY). Criticisms of MSY lead to this new goal which allowed managers to manage for optimum catch, optimum economic efficiency, optimum recreational opportunites, optimum ecological stability.

  Problem:

  – So broad in concept it was meaningless – optimum never really defined

Goals of Fishery Management:
Some other Guiding Principles

- John Gulland
  - Any collapse of the fishery must be avoided
  - The catching capacity of the fishery must be limited
- Other Guidelines
  - Divide the catch among users as fairly as possible
  - Accomplish the division of catch while maintaining the resource at a level acceptable to user groups

Keep this in mind because we will take some time to discuss this further in few minutes.

What Tools Do We Have To Accomplish Fishery Management Goals?

- Size limits
- Creel Limits (Catch Quotas)
- Season Limits
- Area Restrictions (Sanctuaries)
- Gear Restrictions
- Prevention of Stocking
- Stocking
- Habitat Enhancement
- Fish Removal

How many of these deal directly with fish and how many are directed at people?

Which of the Fishery Management Tools Apply to People and which apply directly to the fish?

- Size limits
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- Season Limits
- Area Restrictions (Sanctuaries)
- Gear Restrictions
- Prevention of Stocking
- Stocking
- Habitat Enhancement
- Fish Removal

→ •People

→ •Fish

Example of SIZE, CREEL, and SEASON limits.

SEASONS FOR LAKE SUPERIOR AND ITS TRIBUTARIES BELOW POSTED BOUNDARIES

SPECIES	OPEN SEASON	POSSESSION LIMIT
LAKE TROUT	Dec. 1, 2002- Sept. 30, 2003 and Dec. 1, 2003- Sept. 30, 2004	3
CHINOOK COHO, PINK ATLANTIC SALMON	Continuous	5 combined, (only 1 can be an Atlantic salmon) min. size limit 10"

Example of GEAR RESTRICTIONS.

Regulations

- Two lines may be used on Lake Superior, except only one is allowed within 100 yards from where a tributary stream enters the lake. Also, only one line may be used in tributary streams.
- Anglers are restricted to a single hook only—no treble hooks—on Lake Superior tributary streams and rivers up to the posted boundaries. Exceptions are the St. Louis River (St. Louis and Carlton

Example of AREA RESTRICTIONS (SANCTUARIES).

EXPERIMENTAL AND SPECIAL REGULATIONS

Knife River (St. Louis and Lake Counties)

FISH SANCTUARY: River and tributaries upstream from Lake County Road 9 open to fishing from May 15 through September 30 only. The river between the cables upstream of the fish trap open to fishing from June 1 through August 31. U.S. Highway 61 bridge downstream to the cable below the fish trap is permanently closed to fishing.

Example of PREVENTION OF STOCKING or moving aquatic plants and animals.

EXOTIC SPECIES LAWS (prohibitions and restrictions)

Transportation, Launching, and Bait Harvest

It is ***unlawful*** to:

- transport aquatic plants, ruffe, round goby, zebra mussels, or other *prohibited* exotic species (see list below) on public roads;
- transport infested water (including in livewells and bait containers) from infested waters;
- transport live crayfish to other waters or to use them as bait in waters other than where they were taken;
- launch a watercraft with aquatic plants, zebra mussels, or *prohibited* exotic species attached;

Fishery Management = People Management

Most of the really large problems of natural resource agencies originate in the field of human relations

- “We know how to manage the fish, but not the people”
- “Fishery management is 90% managing the public and 10% managing the fish”

Eras or Periods in Natural Resource Management in America

- Era of Abundancy – prior to 1850 (no worry about supply)
- Era of Exploitation – 1850-1900 (fish out and look elsewhere)
- Era of Preservation – 1900-1935 (protect rather than use wisely)
- Era of Harvest and Habitat – 1935-1980s (environmental manipulation)
- Era of Human Management – Present (concentrating on public involvement and education.

Fishery Management = People Management

- In this era public relations is extremely important. User groups must know and understand what is being done, how it is being done, and why it is being done.

- Natural Resource Agencies are different from businesses that sell goods to the public because the “goods” are already owned by the people of the state (and in some cases tribal entities). Therefore, natural resource agencies must sell ideas and services (similar to a business consultant).

With the diversity of interests and users of Great Lakes fish, it becomes difficult to convince everyone that the management services provided are appropriate and effective.

Fishery Management = People Management

Some of the Great Lakes Fishery User Groups/Stakeholders

- Charter Captains

Fishery Management = People Management

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- Environmental Organizations

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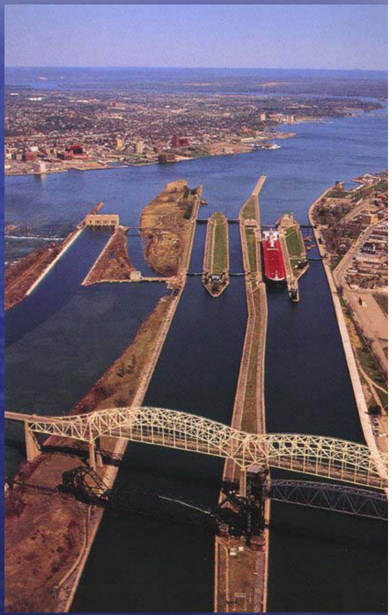
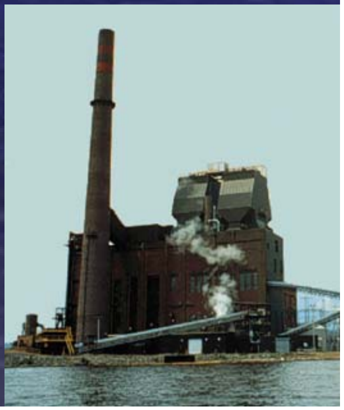
- Environmental Organizations
- Industrial Users -- like power companies, water born commerce, waterfront development





Fishery Management = People Management

- Given the public ownership of the Great Lakes fishery resources and the responsibility for managing the fishery, what should be our overarching goals or guiding principals? Think broadly across all the Great Lakes and all the users/stakeholders.

Group Discussion – write down some goals and guiding principles acceptable to everyone in your group.

Time out for Discussion
Break into groups

Each Group should write down some fishery management goals and guiding principles acceptable to everyone in your group.

Fishery Management = People Management

Discussion Items:

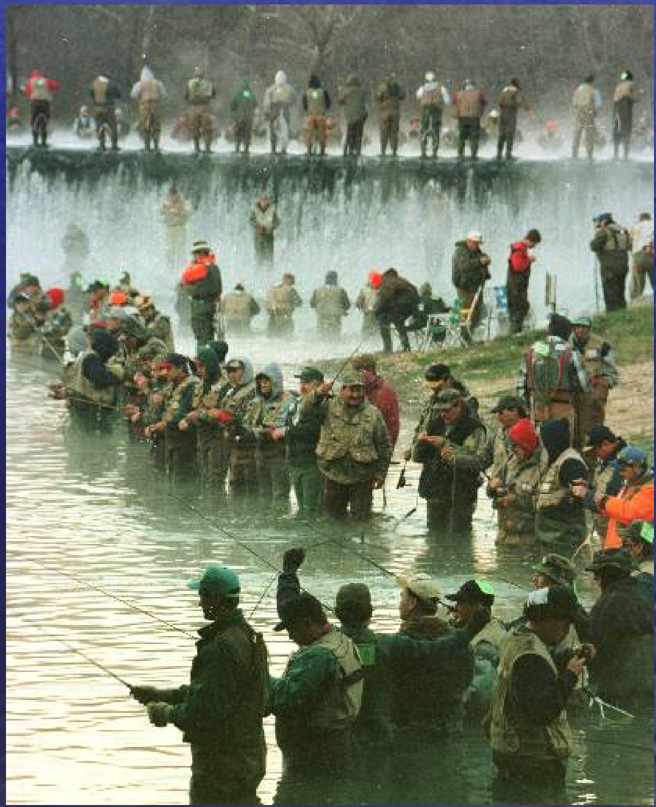
- Was it difficult to identify goals and guiding principles acceptable to everyone? If so, why?
- How can appropriate decisions regarding appropriate management be made without guiding principles and goals?
- Is legislative and judicial management of Great Lakes fisheries the best approach?
- Are there other alternatives?

Unit Two

What makes fish a renewable resource?

Concepts on which Fishery Management is Based

- Exploited population – fish harvested for food, sport, extermination



Some people react negatively to the term "exploited" because it carries a negative image, but it simply refers to harvested fish.

Parameters Effecting an Unexploited Population

- Growth
- Recruitment
- Natural Mortality

Growth →

Recruitment →

Stock of Fish

→ Natural Mortality

Parameters Effecting an Exploited Population

- Growth
- Recruitment
- Natural Mortality
- Fishing Mortality

Growth → Stock of Fish → Natural Mortality

Recruitment → Stock of Fish → Fishing Mortality

Other Fishery Management Concepts

- Model = mathematical representation of response of fish stocks to different conditions or changes in these parameters
- Population Dynamics = population changes

Generalized Fishery Models

- Stock (at time 1) + Growth + Recruitment – Fishing Mortality – Natural Mortality = Stock (at time 2)

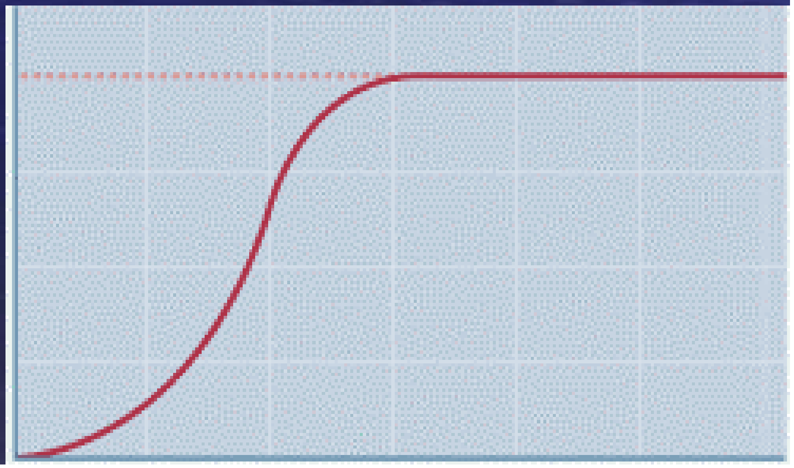
- $\frac{\text{Stock Time 1 + Stock Time 2}}{2}$ = Mean Stock

- Mean Stock x Fishing Mortality = Yield

The terms modeling and models are frequently misunderstood. They can be very complex or very simple. They can be used to **describe** various parameters or for **prediction**.

One More Fishery Management Concept

- Carrying Capacity – basic ecological principle governing fish populations
- Definition – Maximum poundage of a given species of fishes that a limited and specific habitat may support during a stated interval of time.



Carrying Capacity

- Description – fish generally have an innate capacity to increase given ideal conditions. As an example they produce many more eggs than needed. But, density dependent factors control population – prevents a fish population from continuing to grow unchecked. As population density increases, there is less food, less supportive habitat and increased stress, disease, and parasites. Many times as food declines the adults feed directly on smaller members of their own species.

Natural Variability

- While Carrying Capacity places an upper limit to the biomass of fish able to be supported, there is typically a great deal of Natural Variability. Natural Variability in the number of young produced each year occurs because of:
  - Weather during spawning or juvenile development
  - Food availability
  - Water flow
  - Predation
- Variation in year class strength is more apparent when few age classes make up the fishery.

Another Definition

- Standing Stock – the poundage of a given species or complex of species of fishes in a body of water at a specific moment.
- Determined by many factors such as:
  - Fertility
  - Growing season
  - Area
  - Mean and maximum depth
  - Shore development
  - Mortality
  - Kind of fish
  - Number of species present
  - Hard or soft water
  - Flushing time
  - Growth
  - Recruitment

Another Term

- Production = Total amount of tissue added to a population in a given area and period of time regardless of whether it survives to the end of that time period.

Just one more Term

- The harvesting of fish can actually result in a surplus of fish flesh – called Surplus Production.
- Also known as:
  - "The biological basis for a fishery" or
  - "A fish harvest creates its own surplus production"

So Who Cares?

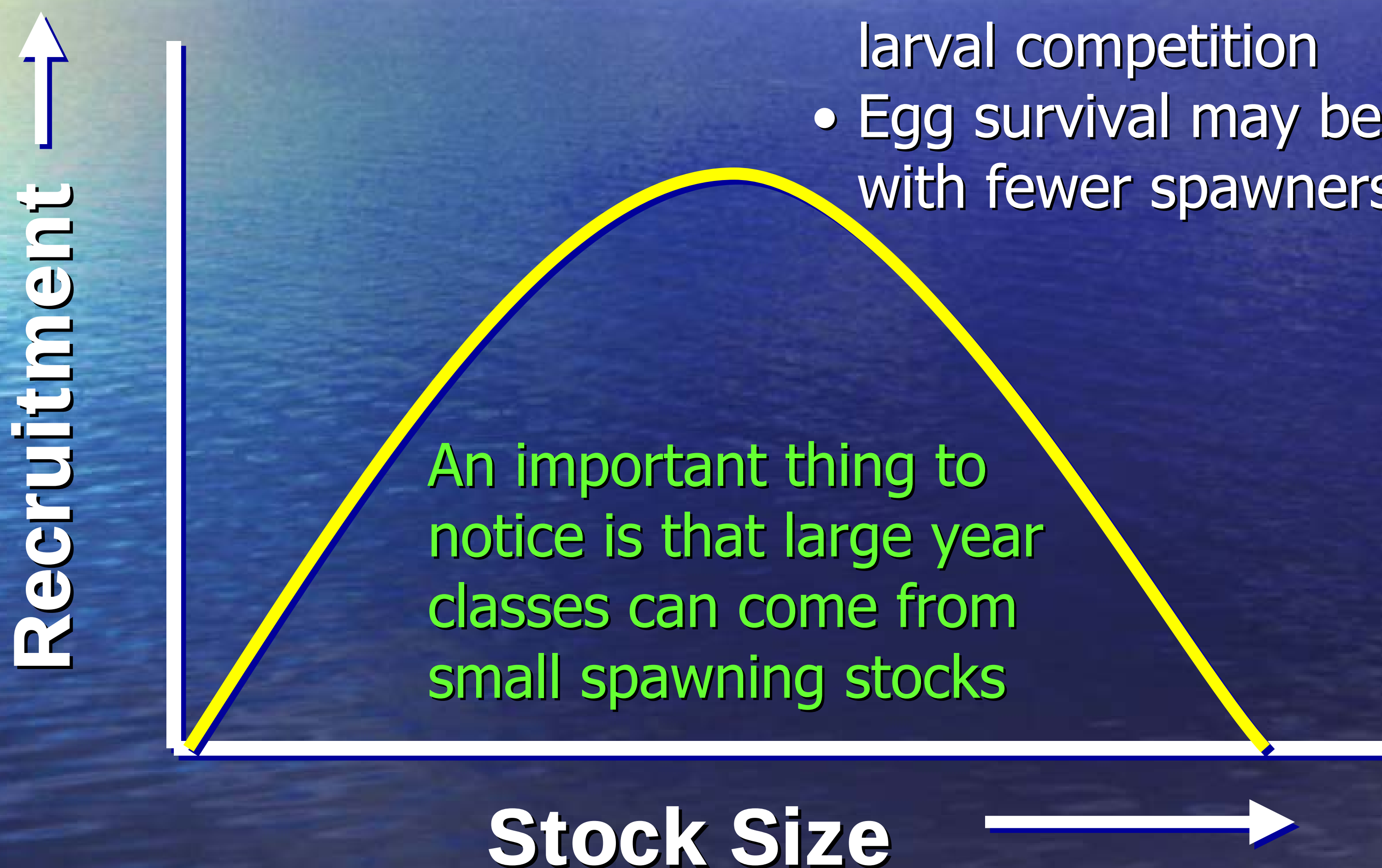
- Surplus Production is the basis for fishery management .
- A fish stock compensates for changes in standing stock size – called Compensatory changes.
- Therefore, as you increase fishing pressure, a fish stock increases production but only up to the point where it is able to compensate for increased harvest then it declines.

How Does a Fish Stock Compensate for Harvest?

- Faster growth
- Increased recruitment
- Decreased natural mortality

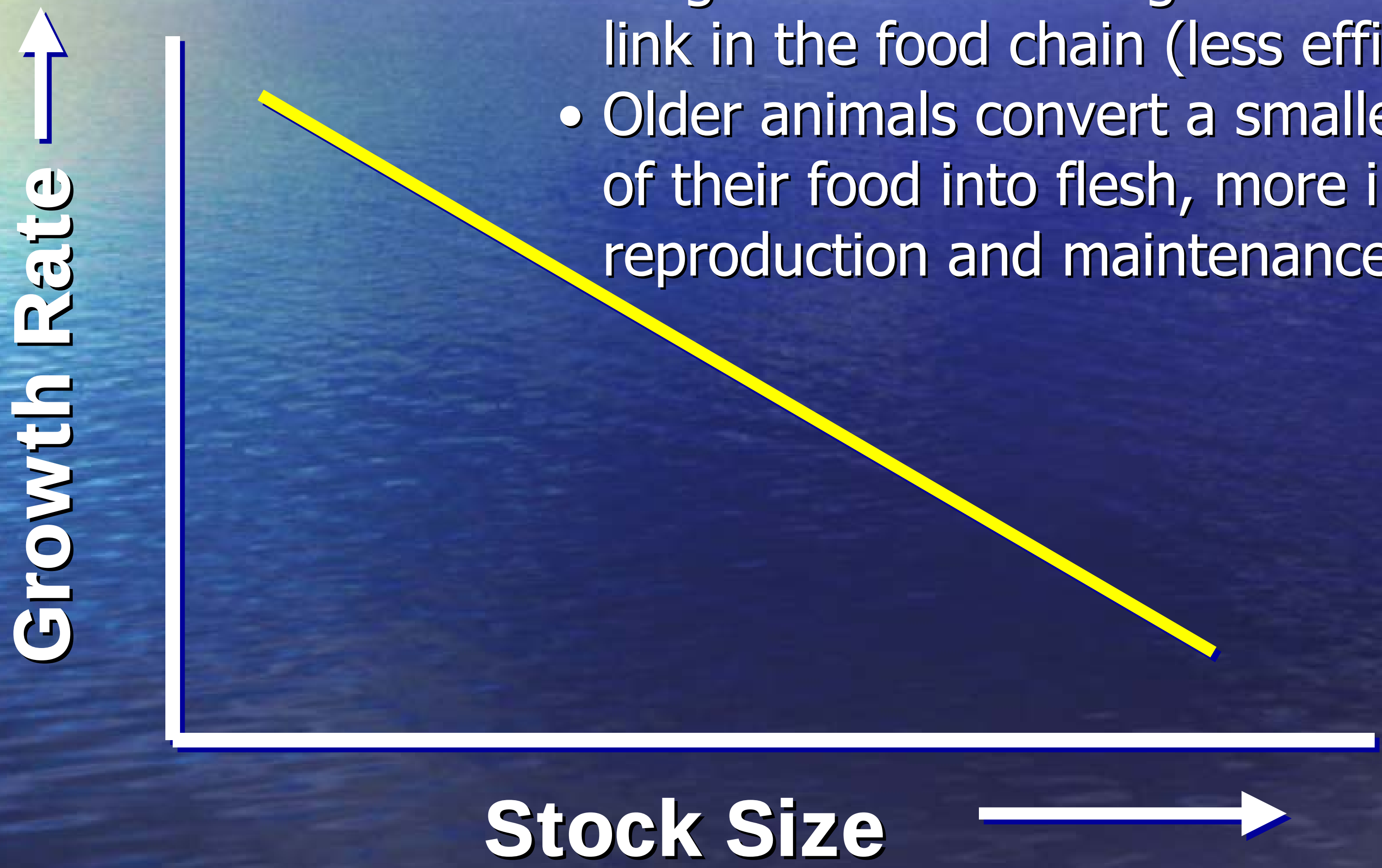
Recruitment Compensation

- Fewer eggs laid may produce more recruits due to less larval competition
- Egg survival may be greater with fewer spawners



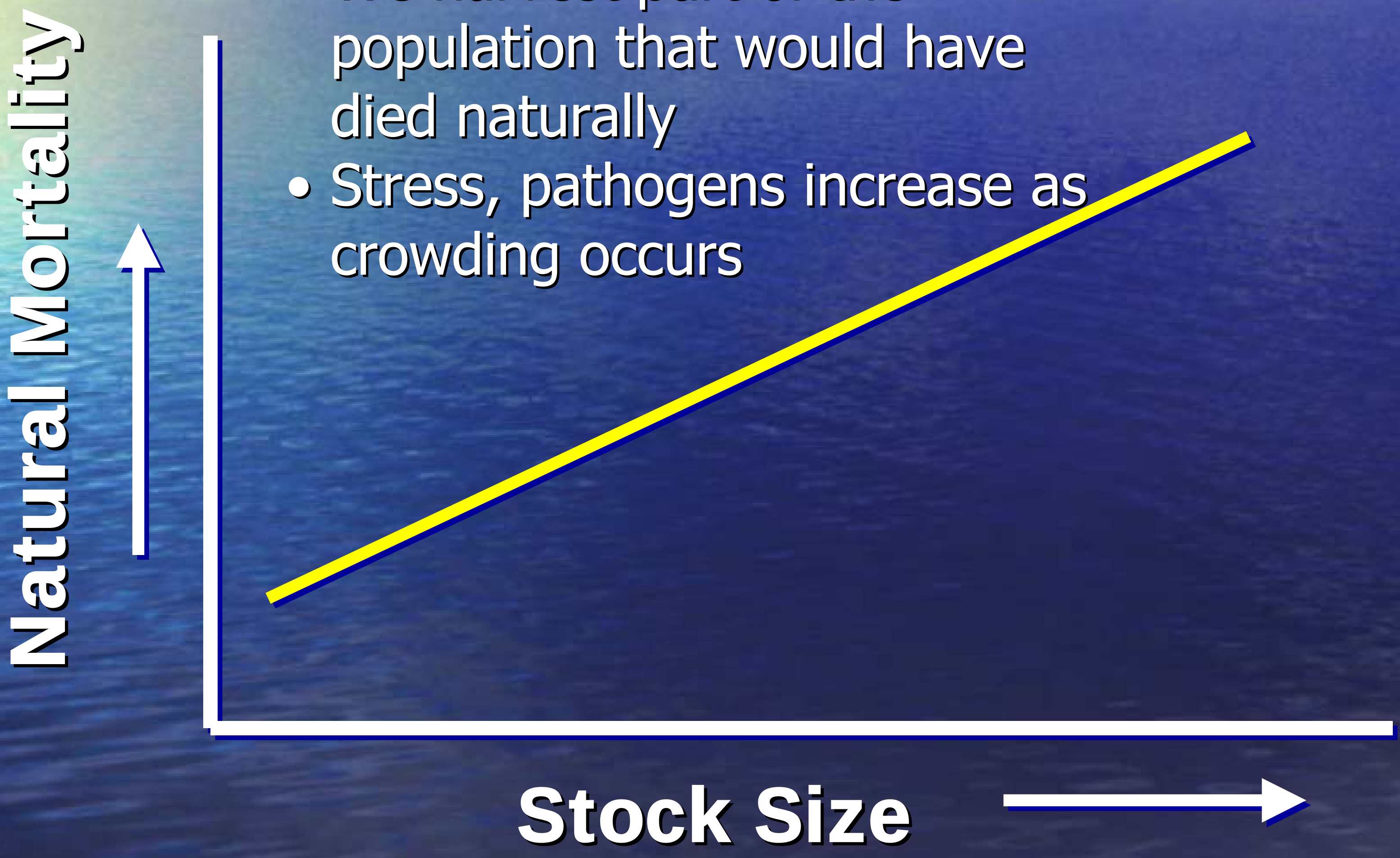
Growth Compensation

- When food supply is limited, food is less efficiently converted to flesh.
- Large animals eat larger food –another link in the food chain (less efficient)
- Older animals convert a smaller fraction of their food into flesh, more into reproduction and maintenance

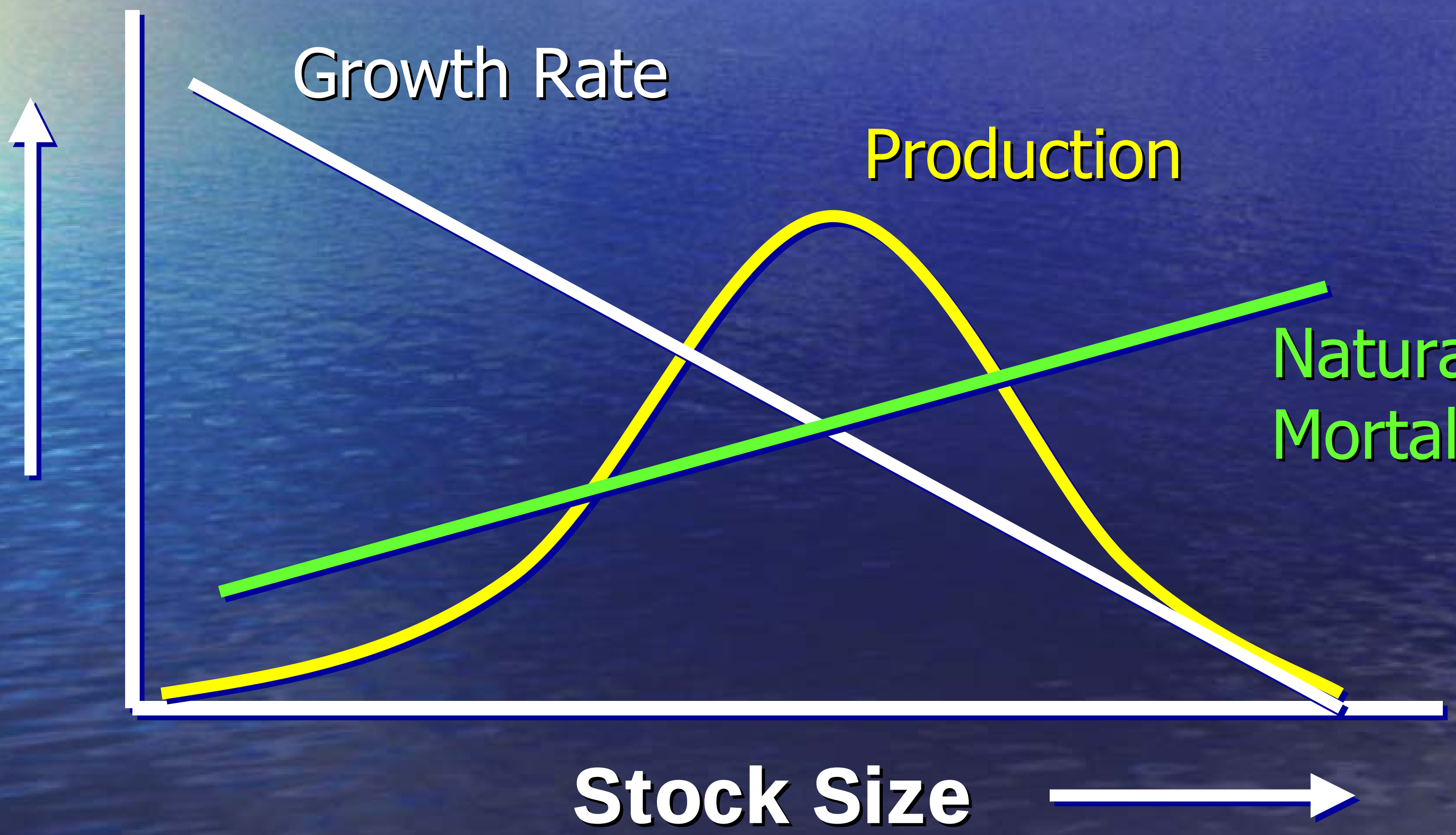


Natural Mortality Compensation

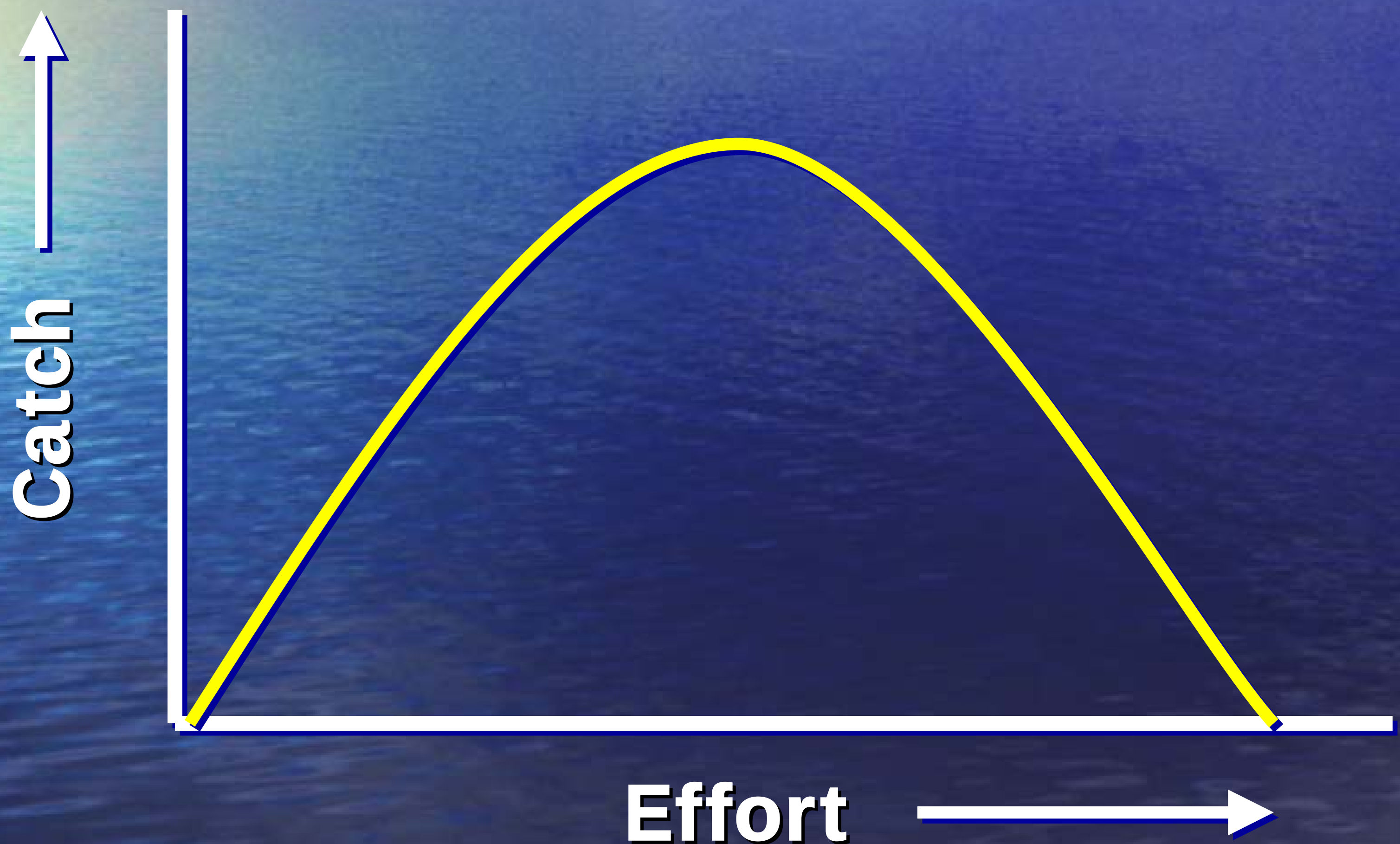
- We harvest part of the population that would have died naturally
- Stress, pathogens increase as crowding occurs



Relationship of Stock Size to Growth Rate, Production, and Natural Mortality



Surplus Production



Surplus Production Example
Biological Basis for a Fishery

Stock Yr 1 + Growth + Recruitment – Natural Mort. = Stock Year 2
10,000 lbs + 10,000 lbs + 2,000 lbs – 12,000 lbs = 10,000 lbs

Fishery started

Stock Yr 1 + Growth – Fish Mort. – Natural Mort. + Recruitment = Stock Yr 2
10,000 lbs + 10,000 lbs – 10,000 lbs – 6,000 lbs + 2,000 lbs = 6,000 lbs

Note:

We are depleting the stock and that 6,000 lb were caught that would have died naturally.

But if natural mortality is density dependant and is reduced and growth is increased because of fewer and smaller fish, and recruitment increases slightly then:

Stock Yr 1 + Growth – Fish Mort. – Natural Mort. + Recruitment = Stock Yr 2
10,000 lbs + 11,500 lbs – 10,000 lbs – 4,000 lbs + 2,500 lbs = 10,000 lbs

So now we still have a standing stock of 10,000 lbs but we also have 10,000 lbs of fish harvested.

But, what happens to age and size structure?

Surplus Production Summary

- Surplus production demonstrates how and why fish are a renewable resource and demonstrates the factors critical to fishery management.
- Next we will look at some of the tools and techniques used by fisheries management.

Unit Three

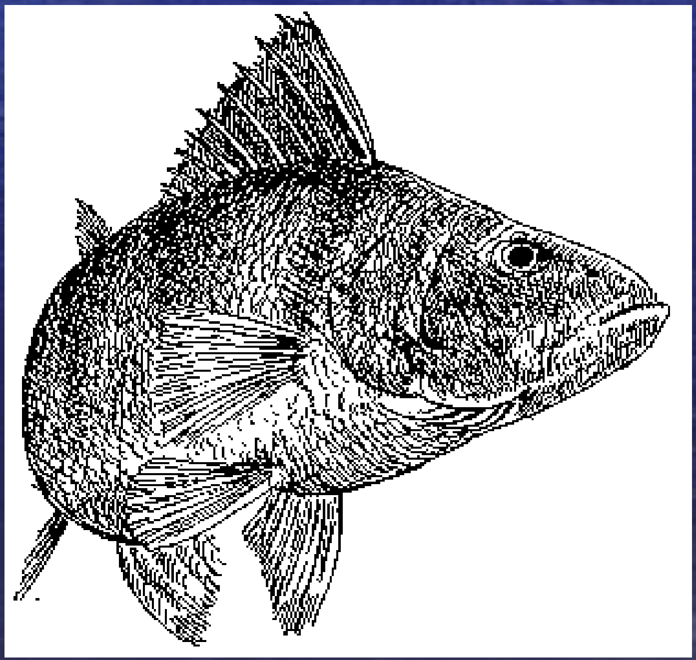
Tools of Fishery Management

Age, Growth and Death

- To manage a fishery, the basic information required is:
  - distribution of different ages in the stock of fish
  - Relationship between fish length and age
- Once ages are known then:
  - Growth can be determined
  - Death rate (mortality) can be determined

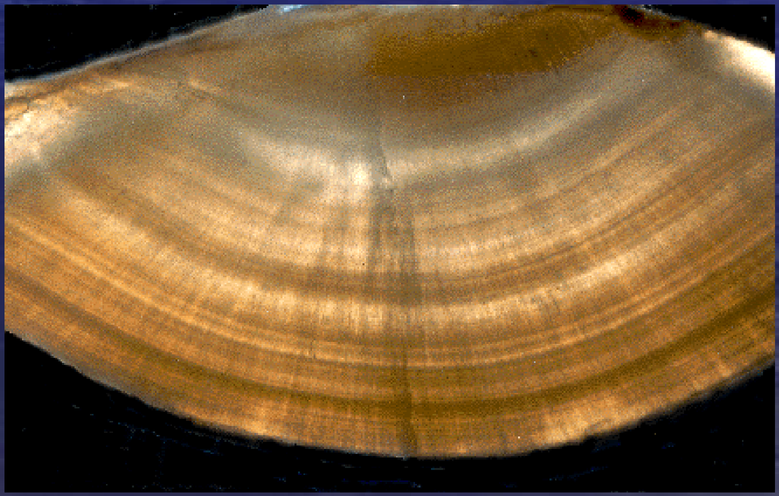
Aging Fish

- Just like people, you can't tell the age of fish by looking at them



Aging Fish

- Just like people, you can't tell the age of fish by looking at them
- Age is determined by looking at scales or bony parts like ear bones (otoliths)



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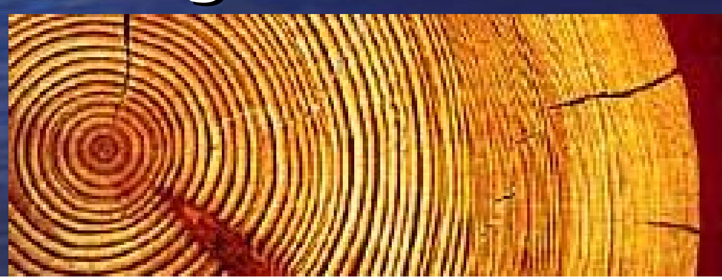
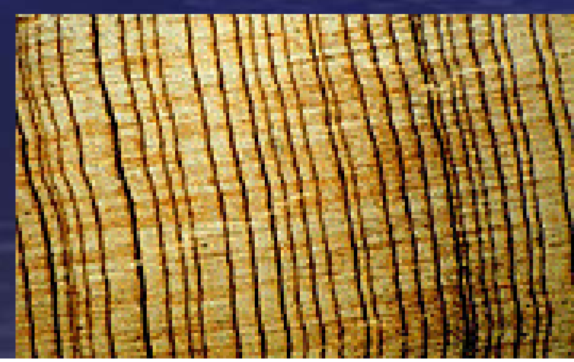
- Growth is recorded like rings on a tree – fish grow fast during the summer and slow during the winter.





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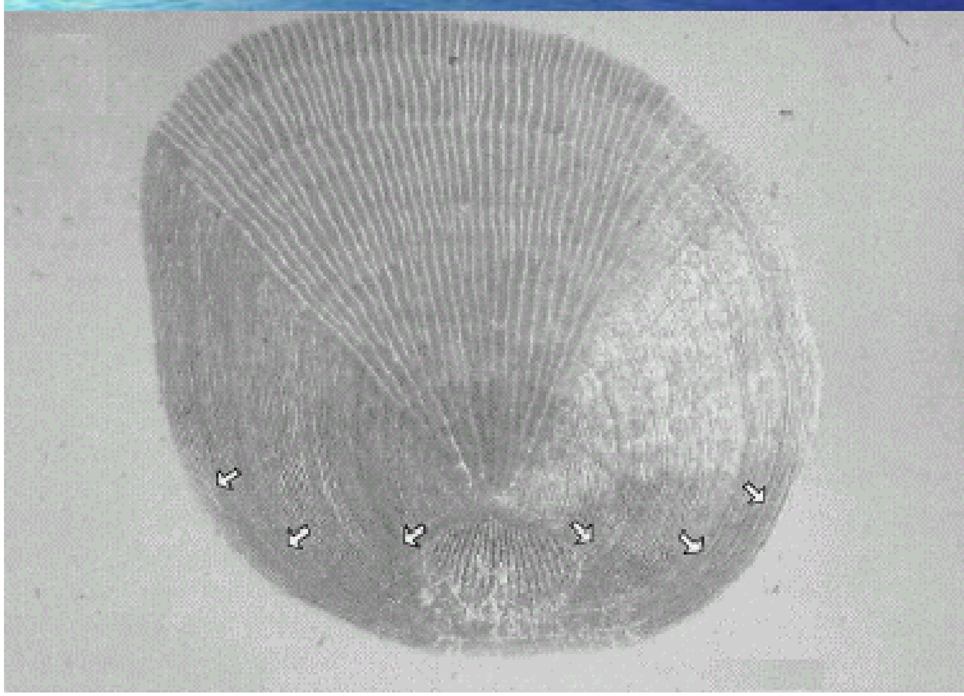
- Age is determined by looking at scales or bony parts like ear bones (otoliths)
- Growth is recorded like rings on a tree – fish grow fast during the summer and slow during the winter.
- Examining length and weight at each age provides an estimate of growth rate.

Annular Marks

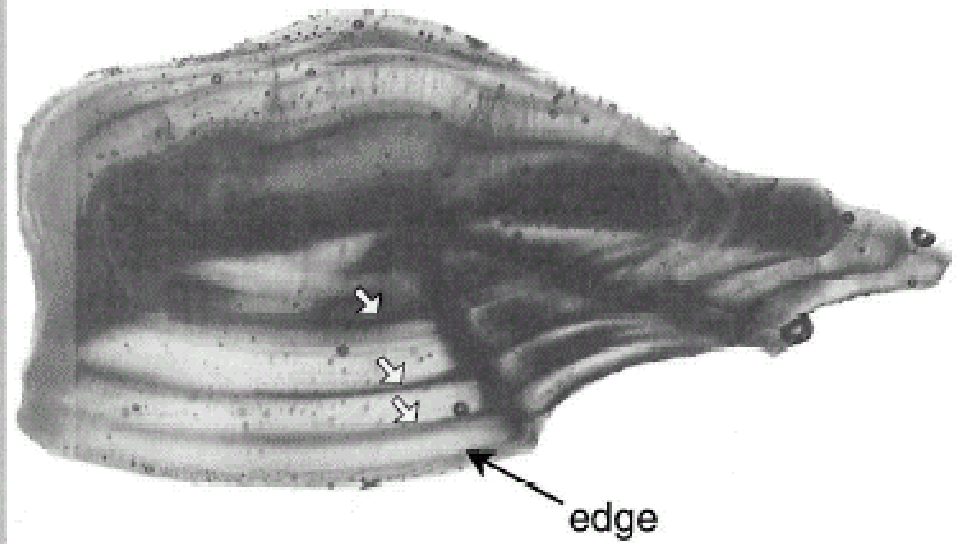
They are both 3+

How old is the fish that the scale and otolith came from?

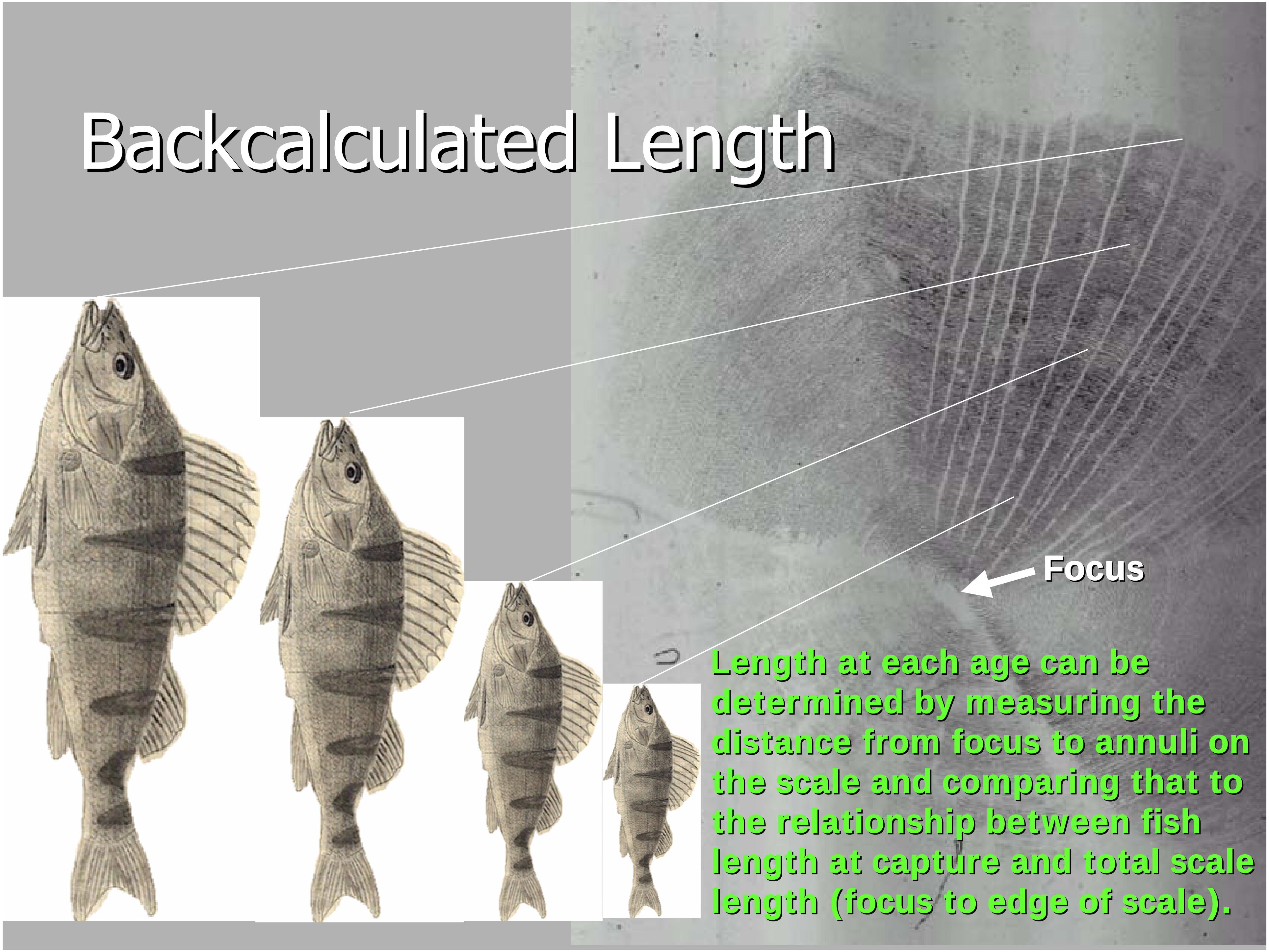
Fish Scale



Fish Otolith



Backcalculated Length

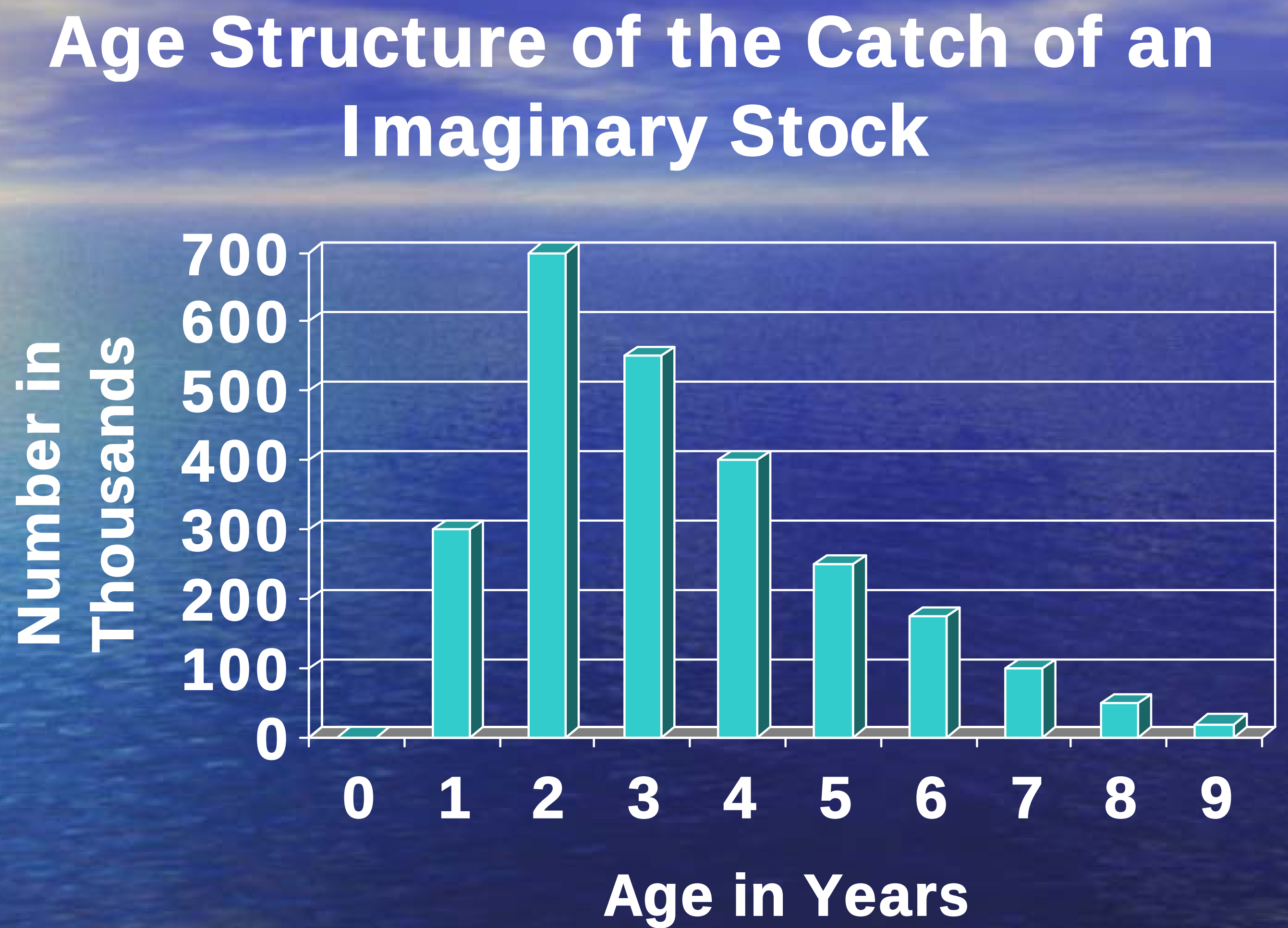


Length at each age can be determined by measuring the distance from focus to annuli on the scale and comparing that to the relationship between fish length at capture and total scale length (focus to edge of scale).

Mortality Rate

- By determining the age structure of the fish harvested, managers can determine mortality rate

Mortality Rate from Age Structure



- The fewer age 1 fish than age 2 indicates age 1 fish are not fully recruited to the fishery.
- Mortality can be determined by the decline in numbers form one age to the next

Mortality Rates and Age Structure?

Suppose a fishery has an annual recruitment of 100 fish, the fish become vulnerable at age II, and after age V they die. This fishery was exposed to a 20% natural mortality rate, but now a 24% fishing mortality has been added which results in a 44% total mortality rate.

Age	Year 1			Year 2			Year 3			Year 4	
	No.	%		No.	%		No.	%		No.	%
II	100	41	44%	100	50		100	53		100	53
III	80	33		56	28	44%	56	30		56	30
IV	64	26		45	22		31	17		31	17
Total	244			201			187			187	

Result of 20% annual mortality

Mortality Rates and Age Structure?

Age	Year 1		Year 2		Year 3		Year 4	
	No.	%	No.	%	No.	%	No.	%
II	100	41	100	50	100	53	100	53
III	80	33	56	28	56	30	56	30
IV	64	26	45	22	31	17	31	17
Total	244		201		187		187	

44%

44%

Able to See Two Important Effects of Fishing on a Fishery

- **Proportion of young fish to old fish has increased**
- **The age structure does not stabilize for as many years as there are age groups in the fishery.**

What does this mean for a fish that lives 20 to 30 years like a lake trout?

Mortality Rates

Annual Percentage	Instantaneous Rate
0	0
10	0.105
30	0.357
50	0.693
80	1.609
90	2.303

- While annual mortality rates are easier to understand, fishery managers must convert them to instantaneous rates for use in mathematical formulas.
  - Z = total instantaneous mortality
  - F = instantaneous fishing mortality
  - M = instantaneous natural mortality

We just want you to be aware that instantaneous rates are frequently used and to be aware of them if you run across them in reports.

Information Needed to Assess a Fishery (in an ideal situation)

- Information about the FISHERY
  - The kinds of fishermen in the fishery (anglers, netters, etc).
  - Pounds of fish caught by each type of fisherman, many years.
  - Effort expended by each type of fisherman, many years.
  - Age structure of fish caught by fisherman type
  - The ratio of males to females in the catch
  - The value of fish to the different type of fishermen
  - The time and geographic area of best catches

Information Needed to Assess a Fishery (in an ideal situation)

- Information about the FISH – biological information
  - Age structure of the stock
  - Age at first spawning
  - Fecundity – number of eggs each age female can produce
  - Ratio of males to females in stock
  - Mortality rates – both natural and fishing mortality
  - Growth rate of fish
  - Spawning behavior – time and place
  - Habitats for larvae, juveniles, and adults
  - Migratory habits
  - Food habits for all ages of fish
  - Estimates of total number and weight of fish in the stock

How Do Managers Collect the Information they Use in Decision Making?

- They collect fish by using gill nets, seines, fyke/trap nets, trawls, electrofishing, creel surveys
  - Identify species, measure length, weight, collect scale samples, collect stomach samples,

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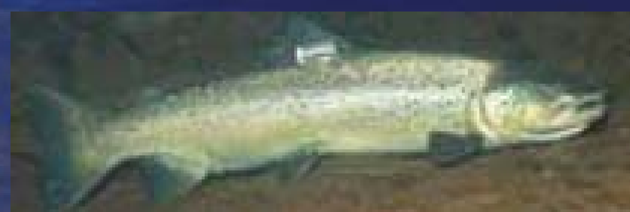
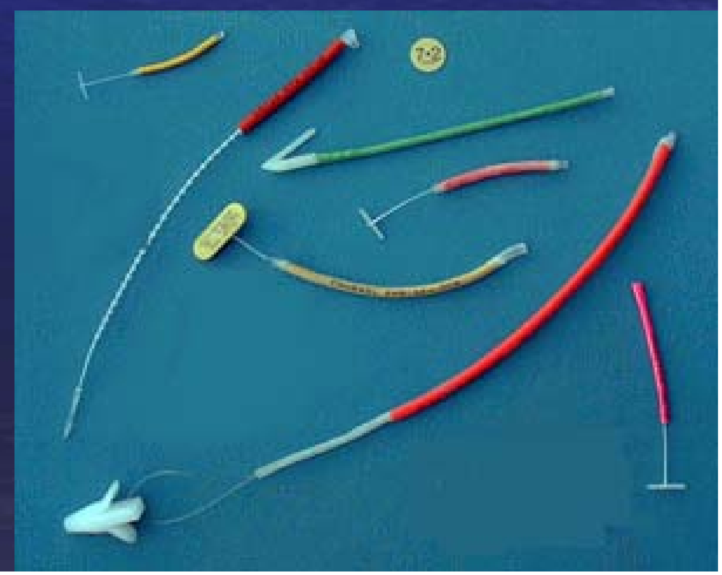
- They do tagging studies

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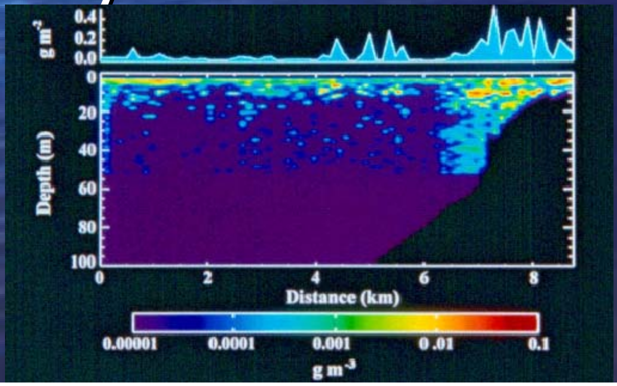
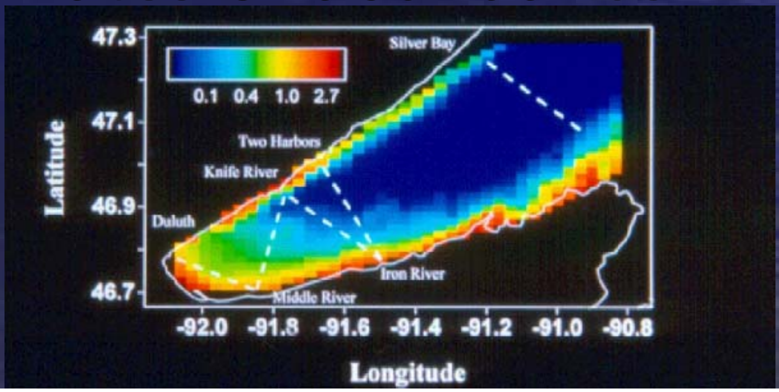
  – Identify species, measure length, weight, collect scale samples, collect stomach samples,
- They do tagging studies
- They collect acoustical estimates of abundance





What is this information Used For?

- Species composition – examine valuable species vs non-valuable species, examine predator/prey relationships
- Lengths and weights – length frequencies provide an idea of age structure, length/weight relationships to determine condition and growth
- Scales or other hard parts – used to determine age and growth. Look to see if growth has changed, how it compares to similar waters, at what age fish mature, how many fish in each age class, environmental growth influences.
- Age composition – estimate total mortality rate

What is this information Used For?
Continued

- Tagging studies – estimate population size, determine migration/distribution, mixing of different stocks, estimate mortality
- Creel surveys – estimate fish harvest
- Stomach analysis – examine food habits, better understand predator/prey relationships
- Sampling young fish can provide estimates of year class strength and recruitment.

Indices

- Because managers can't always directly measure everything they need in order to manage a fishery, they frequently use indices.
  - The index is an indirect measurement taken the same way each year, over many years.
  - Example – lamprey wounding rate.
  - Example – catch of native lake trout per 1000 feet of gill net.
  - Example – number of salmon caught/angler hour
  - Example – acoustic survey of fish biomass
  - Although indices have some drawbacks, they are easy to understand and are useful indicators of change.

Can you think of other indices used in fishery management?

Fishery Management Summary

State and federal agencies act as trustees for public resources such as fish. Fishery biologists assess the health of fishery stocks by reviewing available data or conducting new studies. Catch per-unit effort, indices, age structure, growth rate and death rate are all-important elements of stock assessment.

The stock assessment naturally leads to recommendations for conserving or rebuilding a stock. These recommendations often rely on social, political, economic, and legal considerations.

Unit Four

Why does carrying capacity vary from lake to lake?

Why Does Fish Production Vary From Lake to Lake

The capacity of a lake to produce fish (its carrying capacity) is influenced by three principal factors

- Morphometric Factors
  - Depth, surface area, volume, shoreline development, etc.
- Edaphic Factors
  - Nutrient availability
- Climatic Factors
  - Temperature, sunlight, growing season, precipitation, ice cover, etc.

Morphoedaphic Index

Canadian Biologist found that a lake's ability to produce fish could be fairly accurately predicted by two factors:

1) Mean Depth (in feet)
   - A morphometric feature
2) Total Dissolved Solids (in ppm)
   - An edaphic feature

Climate was not used because it was similar for the lakes studied.

Definitions

- Mean Depth – Average depth of the lake expressed in feet
- Total Dissolved Solids – Often known as filterable residue or residue on evaporation. Average value of surface water samples taken and filtered to remove all dissolved materials. The material filtered out is weighed and expressed in parts per million. Does not include suspended solids.

Morphoedaphic Index (MEI)

$$\frac{\text{Total Dissolved Solids (ppm)}}{\text{Mean Depth (feet)}} = \text{MEI}$$

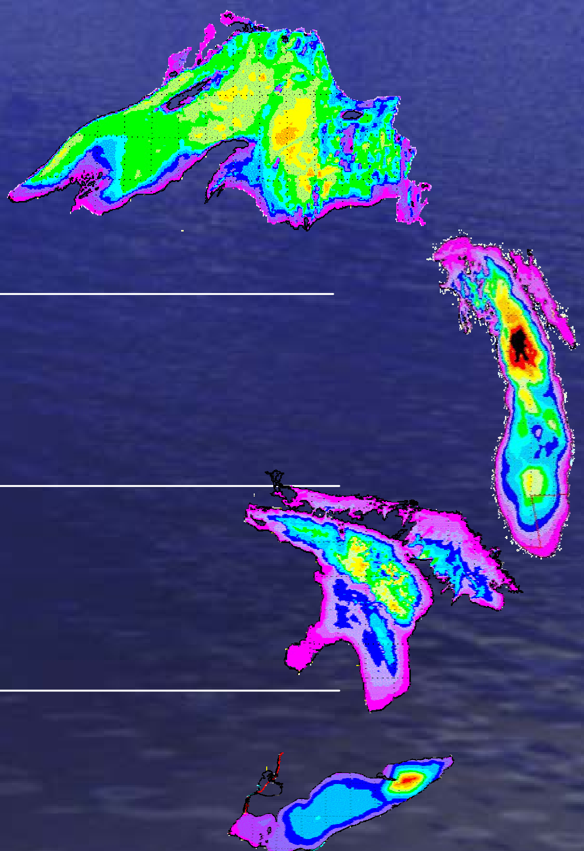
$$\text{Fish Production (lbs./acre/yr)} = 2\sqrt{\text{MEI}}$$

Morphoedaphic Index (MEI)

$$\frac{\text{Total Dissolved Solids (ppm)}}{\text{Mean Depth (feet)}} = \text{MEI}$$

Examples:

Lake Superior	$\frac{60 \text{ ppm}}{487 \text{ ft.}} = 0.12$ MEI
Lake Michigan	$\frac{118 \text{ ppm}}{276 \text{ ft.}} = 0.43$ MEI
Lake Huron	$\frac{117 \text{ ppm}}{195 \text{ ft.}} = 0.60$ MEI
Lake Erie	$\frac{196 \text{ ppm}}{58 \text{ ft.}} = 3.38$ MEI



Morphoedaphic Index (MEI)

Fish Production (lbs./acre/yr) = $2\sqrt{MEI}$

Examples:

Lake Superior	$2\sqrt{0.12\ MEI}$ = 0.69 lbs/acre/yr
Lake Michigan	$2\sqrt{0\ .43\ MEI}$ = 1.31 lbs/acre/yr
Lake Huron	$2\sqrt{0.60\ MEI}$ = 1.55 lbs/acre/yr
Lake Erie	$2\sqrt{3.38\ MEI}$ = 3.67 lbs/acre/yr

Morphoedaphic Index (MEI)

The previous comparisons between the lakes were made using rather old data. Try using new information and see how the lakes compare. Also examine areas of one lake versus the whole lake. For example compare Green Bay estimates to Lake Michigan or Saginaw Bay to Lake Huron. Do you think changes caused by zebra mussels will be reflected in the MEI?

Morphoedaphic Index Summary

- Fish production is limited by lake morphometry and fertility
- No matter how many fish are stocked, a lake only has the capacity to produce within its capacity (carrying capacity)
- Fish management must consider the lake’s capacity for fish production
- Management can alter the emphasis of the fishery but can’t change the basic productivity of a lake.