



5.8 MEAT PRODUCTION METHODS

College Board Topics 5.7, 5.8, and 5.16

Related Readings pg 249 -252 and 437-442

Objectives and Essential Knowledge

ENDURING UNDERSTANDING

EIN-2

When humans use natural resources, they alter natural systems.

LEARNING OBJECTIVE

EIN-2.H

Identify different methods of meat production.

EIN-2.I

Describe the benefits and drawbacks of different methods of meat production.

ESSENTIAL KNOWLEDGE

EIN-2.H.1

Methods of meat production include concentrated animal feeding operations (CAFOs), also called feedlots, and free-range grazing.

EIN-2.I.1

Meat production is less efficient than agriculture; it takes approximately 20 times more land to produce the same amount of calories from meat as from plants.

EIN-2.I.2

Concentrated animal feeding operation (CAFOs) are used as a way to quickly get livestock ready for slaughter. They tend to be crowded, and animals are fed grains or feed that are not as suitable as grass. Additionally, feedlots generate a large amount of organic waste, which can contaminate ground and surface water. The use of feedlots are less expensive than other methods, which can keep costs to consumers down.

ENDURING UNDERSTANDING

EIN-2

When humans use natural resources, they alter natural systems.

LEARNING OBJECTIVE

EIN-2.J

Describe causes of and problems related to overfishing.

ESSENTIAL KNOWLEDGE

EIN-2.J.1

Overfishing has led to the extreme scarcity of some fish species, which can lessen biodiversity in aquatic systems and harm people who depend on fishing for food and commerce.

ENDURING UNDERSTANDING

STB-1

Humans can mitigate their impact on land and water resources through sustainable use.

LEARNING OBJECTIVE

STB-1.F

Describe the benefits and drawbacks of aquaculture.

ESSENTIAL KNOWLEDGE

STB-1.F.1

Aquaculture has expanded because it is highly efficient, requires only small areas of water, and requires little fuel.

STB-1.F.2

Aquaculture can contaminate wastewater, and fish that escape may compete or breed with wild fish. The density of fish in aquaculture can lead to increases in disease incidences, which can be transmitted to wild fish.


SUGGESTED SKILL

 *Data Analysis*

5.E

Explain what the data implies or illustrates about environmental issues.

SUGGESTED SKILL

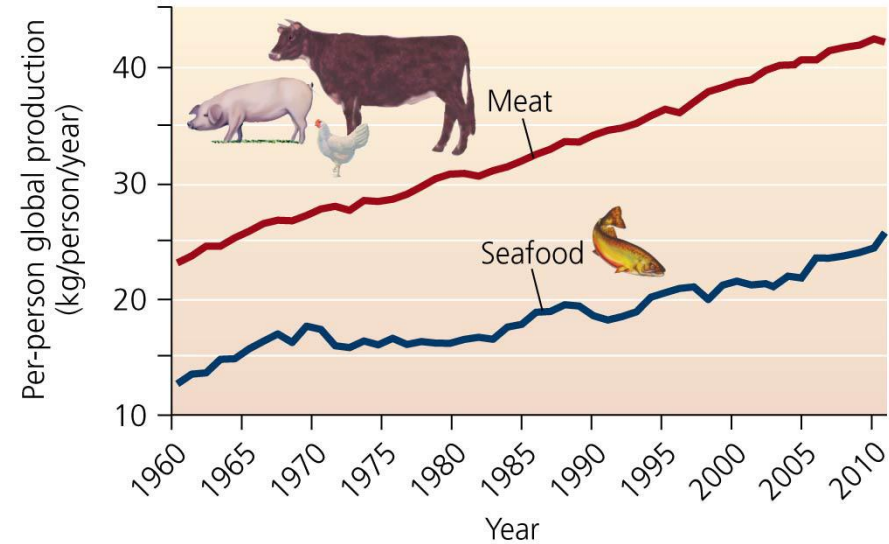
 *Environmental Solutions*

7.C

Describe disadvantages, advantages, or unintended consequences for potential solutions.

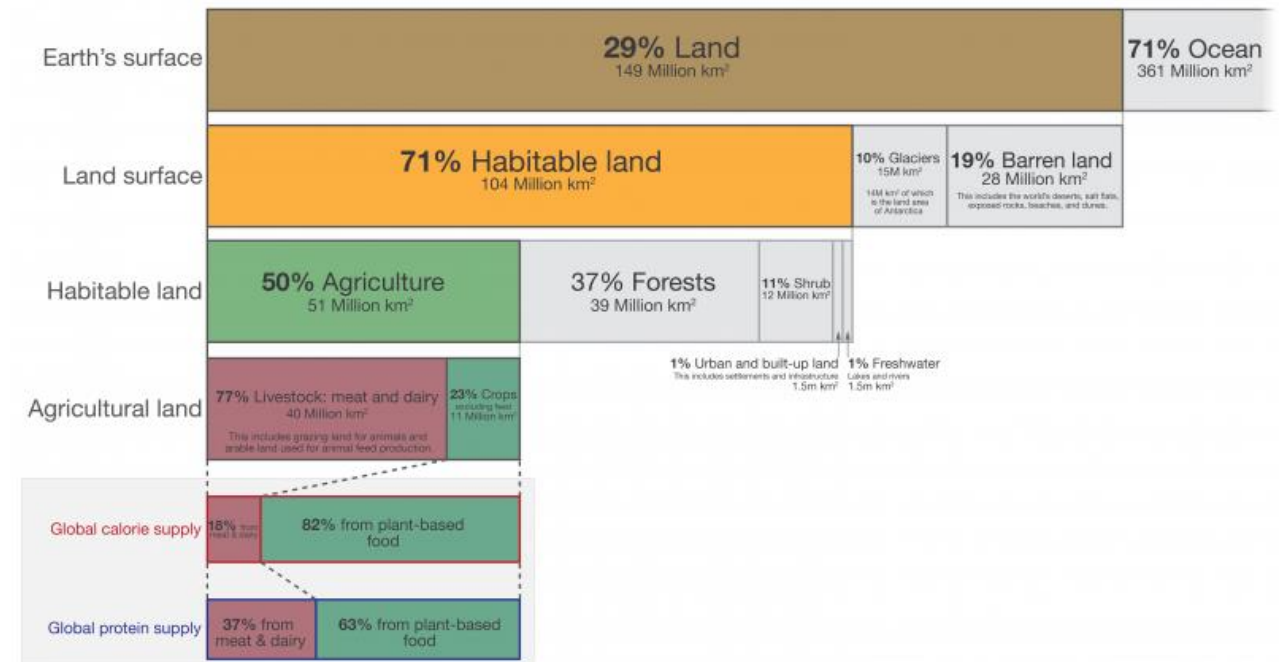
The Demand for Meat

- Since 1950, global meat production has increased fivefold and per capita meat consumption has doubled.
 - 40% of calories come from meat in developed countries, compared to 5% of calories in less developed countries.
 - 50% of habitable land area worldwide is used for meat production, of that, 77% is used for producing meat.
- As wealth and commerce increase, so does meat, milk, and egg consumption.
- Domestic animals raised for food increased from 7.2 billion in 1961 to 27.5 billion in 2011
- Meat consumption is expected to double again by 2050.



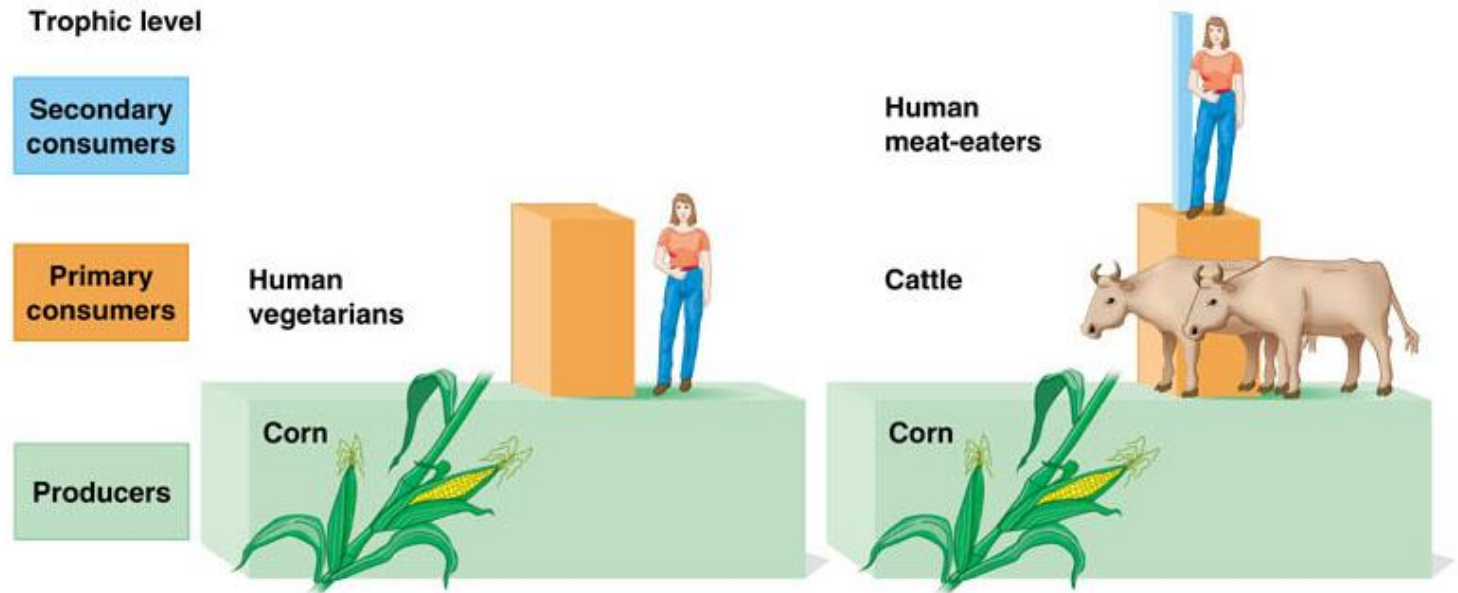
Global land use for food production

Our World in Data



Food choices affect ecological footprints

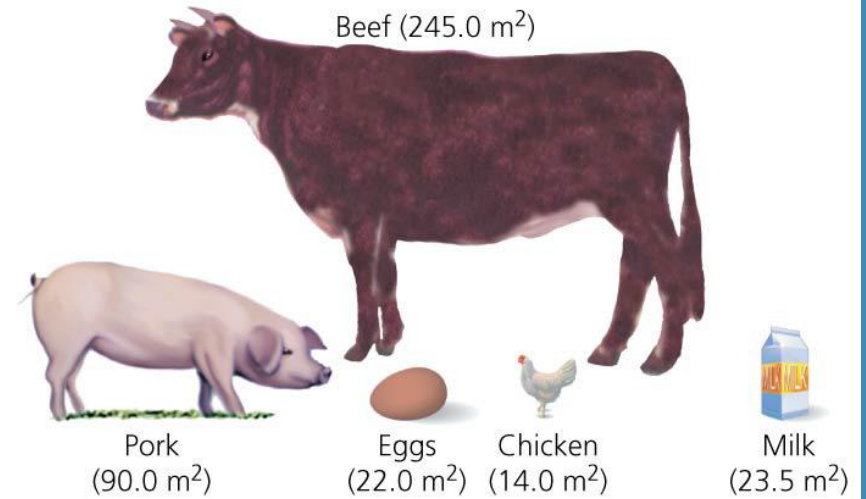
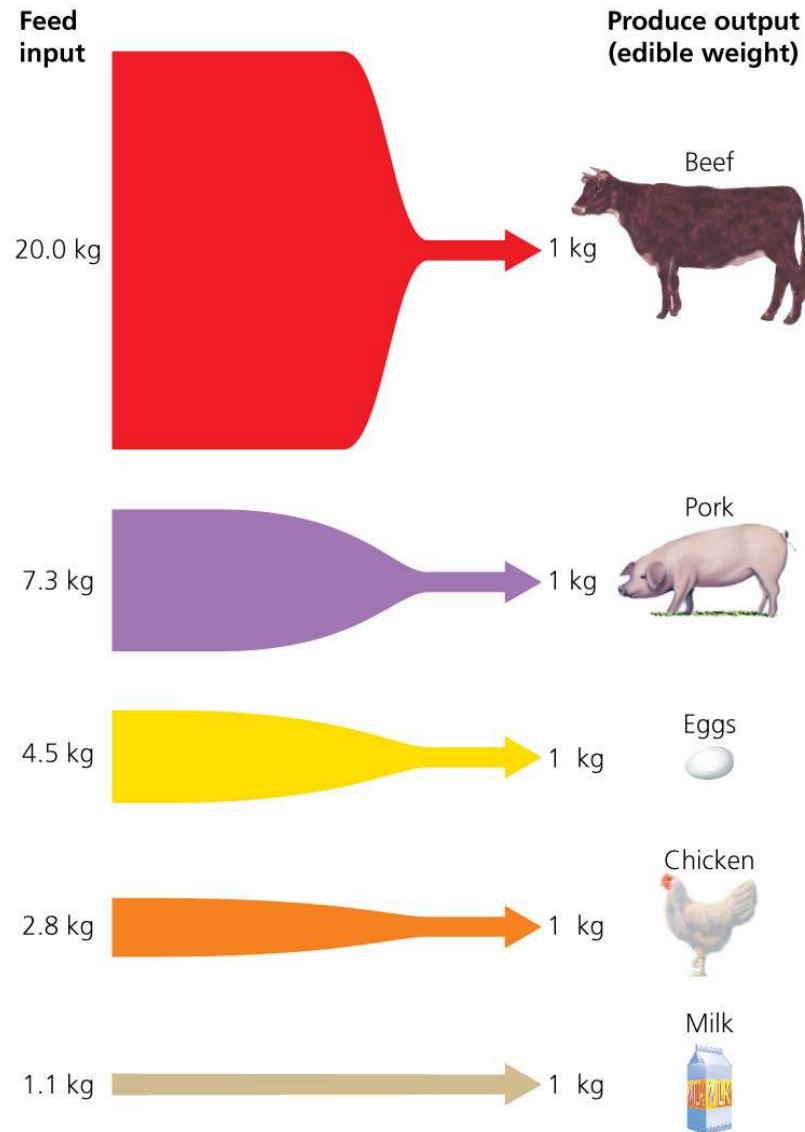
- Eating meat is far less energy efficient than eating a plant based diet.
 - When we eat meat, we eat at a higher trophic level when we consume a plant based diet.
 - On average, 90% of energy is lost from one trophic level to the next.
 - Moving up one trophic level results in an energy loss of 90%.
 - Thus it will require more water and feed, as well as land to grow the feed and house the animals (a calorie of beef requires about 20x more land than producing a calorie of food crops for human consumption).



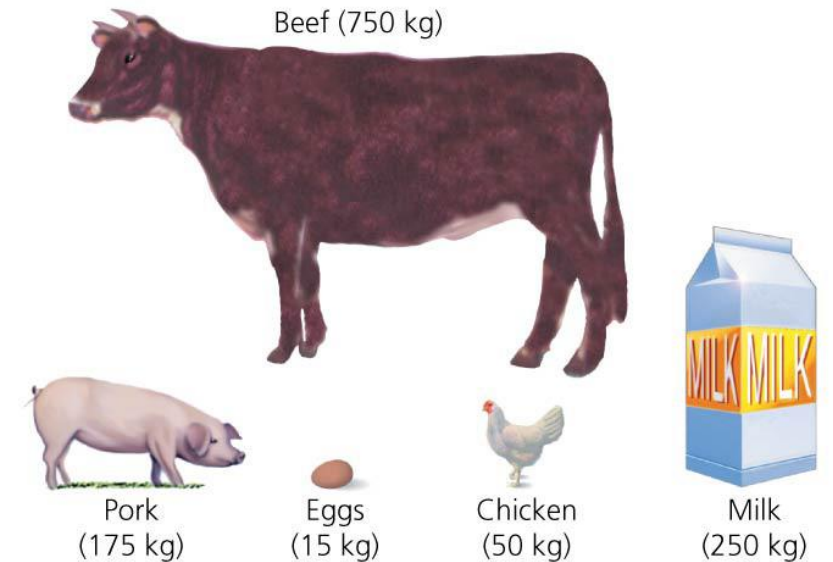
- Eating lower on the food chain reduces the amount of land converted to agriculture and/or has the potential to feed more people using existing agricultural land.
 - Reducing the amount of agriculture required to support the human population also reduce the all of the other impacts of agriculture on the environment.

Food choices affect ecological footprints

- Foods from different animals have different ecological footprints.
 - Some animals convert feed into animal products more efficiently than others.
 - Meat (especially beef) production requires the most feed, water, and land.
 - Producing eggs and milk meat requires the least feed, water, and land.



(a) Land required to produce 1 kg of protein



(b) Water required to produce 1 kg of protein

Concentrated Animal Feeding Operations (CAFO's)

- Rising demand for meat production has increased the use of *concentrated animal feeding operations (CAFO's)*.
 - Animals are raised at very high densities on feedlots.
- Benefits of CAFO's
 - Maximizes land use efficiency and profit (\uparrow kg meat / unit of area).
 - Minimizes cost to consumer.
 - Manure can be used as fertilizers on fields
- Drawbacks of CAFO's
 - Animal feed is designed to be cheap and high calorie (mixture of high starch corn, protein supplements, growth hormones, and antibiotics).
 - Hormones promote rapid growth.
 - High starch (sugar) content causes digestive problems if used for long periods.
 - Due to the high population density of animals in CAFO's, antibiotics are often used preventatively, which accelerates production of antibiotic resistant bacteria.
 - Large volumes of animal waste in a concentrated area can impact air and water quality.

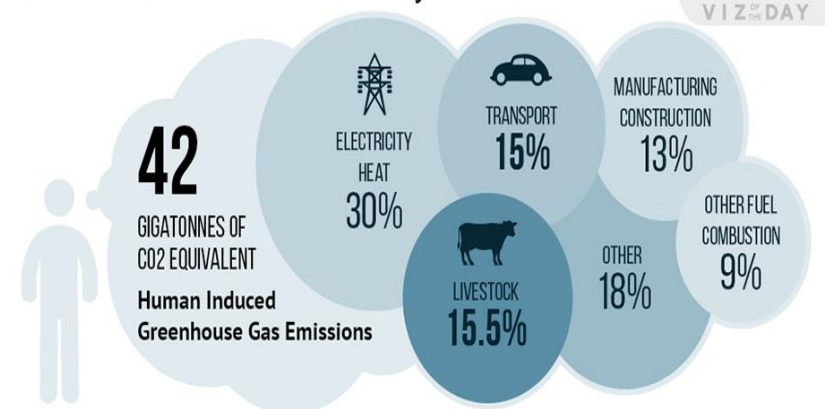


Manure Lagoons

- **Manure lagoons** are large, open storage pits for animal waste (manure) that are necessary with CAFO's due to the large volume of wastes produced in such a concentrated area.
 - Manure lagoons can leak when liners are punctured, supporting walls give way, or flooding rain causes them to overflow.
 - Wastes contain ammonia (NH₃), hormones, antibiotics, and fecal coliform bacteria.
 - Ammonia → eutrophication of surface water.
 - Hormones → surface and groundwater contamination, endocrine disruption.
 - Antibiotics → surface and groundwater contamination, increased antibiotic resistance.
 - Fecal Coliform → surface water contamination, mostly benign, but ***E. Coli*** (a form of fecal coliform) can cause serious illness and death in people.
 - Nitrous oxide (N₂O) → a powerful greenhouse gas produced during denitrification in the nitrogen cycle.
 - Methane (CH₄) → another powerful greenhouse gas produced during anaerobic decomposition (also from cattle burps during digestion)



Emissions of Greenhouse Gases by Sectors



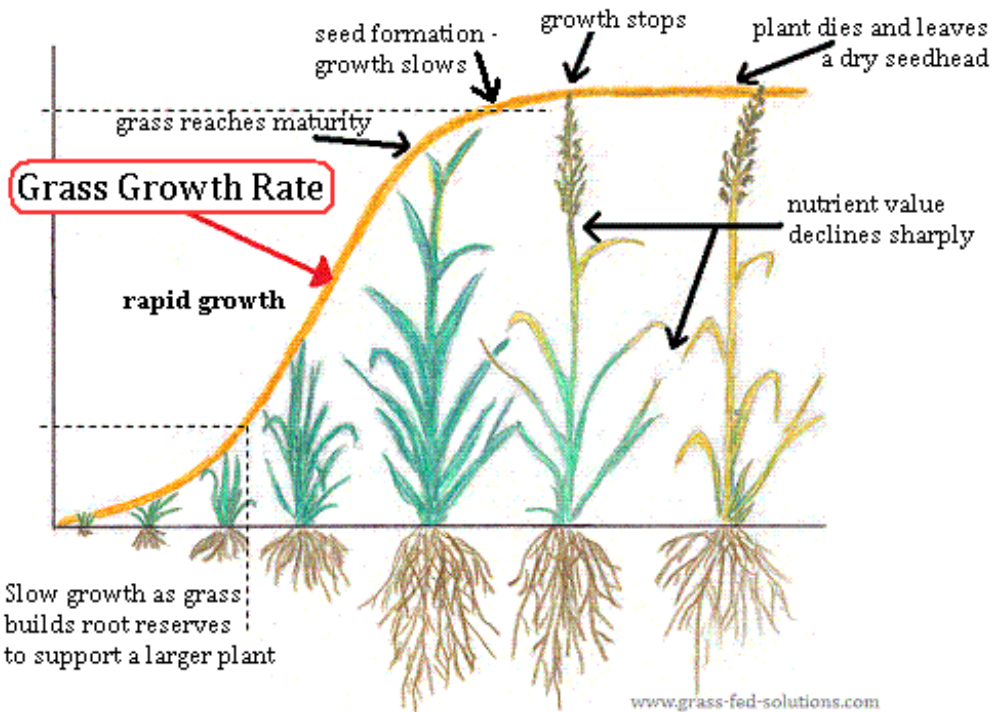
Free Range Grazing

- Animals (usually cattle and sheep) are raised on grass in *pastures* (cultivated) or *rangelands* (naturally occurring grasslands / some scrublands)
 - Has seen a resurgence as consumers became concerned about impacts of CAFO's
 - Animal density is determined by carrying capacity of the land for supporting that specific species.
- Benefits of free range grazing
 - Reduced need for antibiotics since animal density is considerably lower than that of CAFO's
 - Doesn't require additional land use for production of animal feed, and grazing can often occur on land that is too dry to be suitable for crop production.



- Wastes are not as concentrated. Waste is dispersed over large areas where it can more readily decompose and act as fertilizer for the pasture/range plants on which stock feed.
- Hormones are typically not used in free range grazing.
- Drawbacks of free range grazing
 - Requires more land / kg of meat produced
 - More expensive for the consumer
 - Can result in overgrazing of rangelands

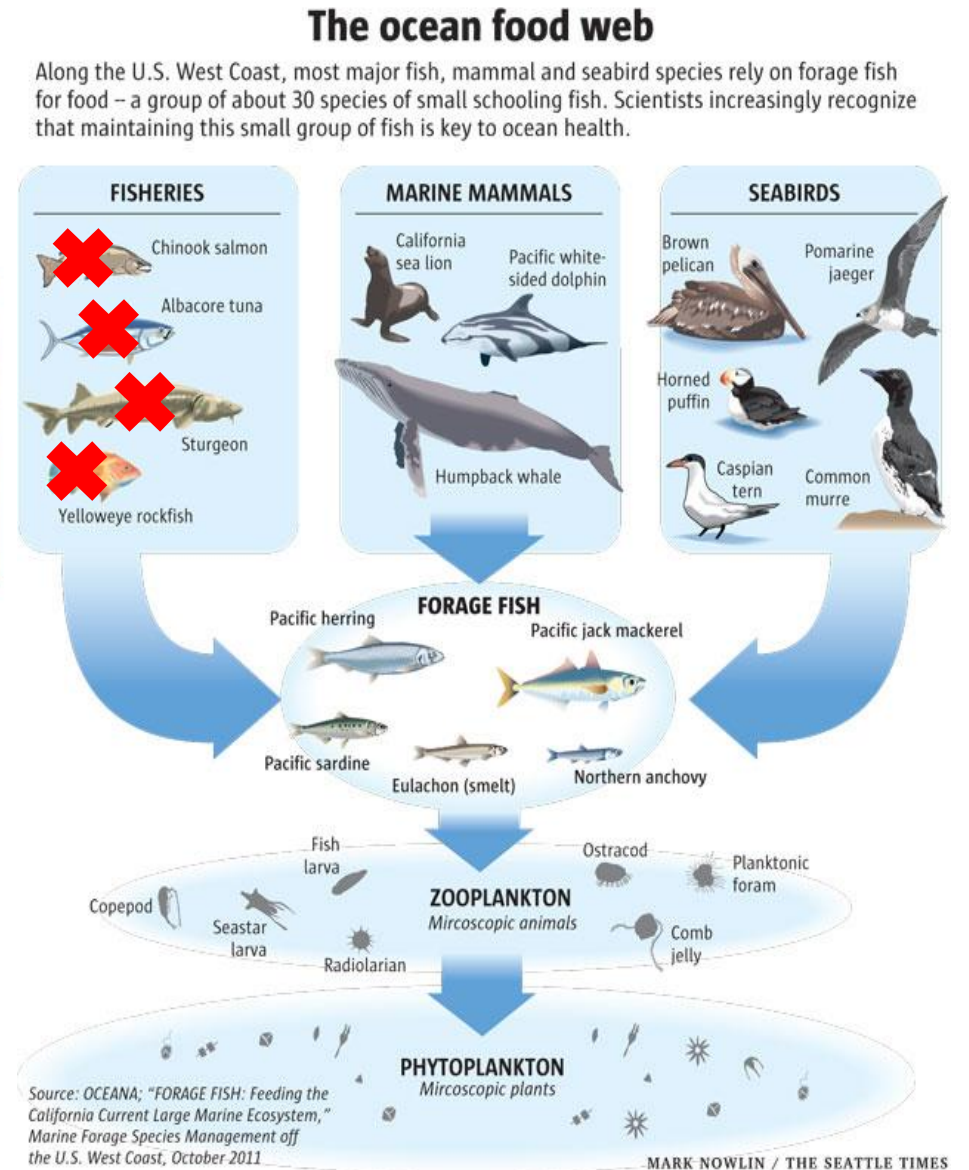
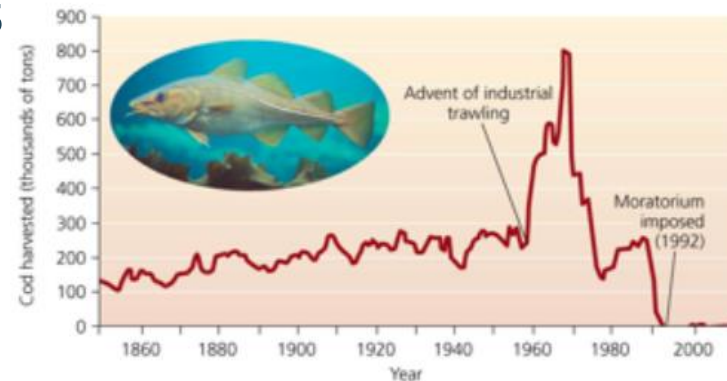
Overgrazing



- Animals consume leaves off of the plants, but don't consume the entire plant. Plants can regenerate the lost growth.
- **Overgrazing** results when the *carrying capacity* of the land is exceeded and plant productivity declines.
 - Some grazing may increase rates of plant growth, too much and the individual plants are damaged or die.
 - Loss of plants increases soil erosion, further reducing plant productivity and carrying capacity of the land.
 - High densities of livestock compact soil reducing infiltration, accelerating runoff, and further reducing productivity and carrying capacity of the rangeland.
 - Overgrazing is the leading cause of soil degradation which can lead to desertification.
- **Rotational grazing**, moving animals between pastures/ ranges, can limit the effects of overgrazing and allow land to recover.

Commercial Fishing

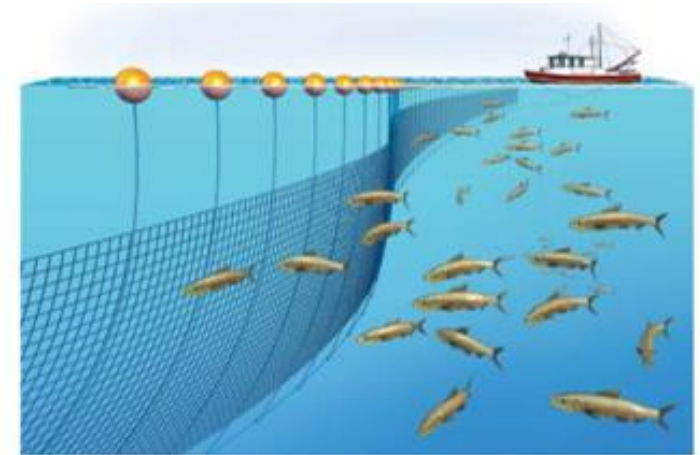
- While much of the world's meat production depends on domestication of animals (CAFO's and grazing), the world's fish supply has traditionally been harvested from wild *fisheries* (freshwater and marine).
- **Overfishing** in the past has led to **fisheries collapse** (population declines $\geq 90\%$) of many wild fisheries.
- Populations may recover very slowly, or not at all.
 - Decreased biodiversity, inability to find mates, inbreeding depression.
 - The effects of **fishing down the aquatic food chain** slows recovery of higher trophic species and results in declines of other species in the food web.



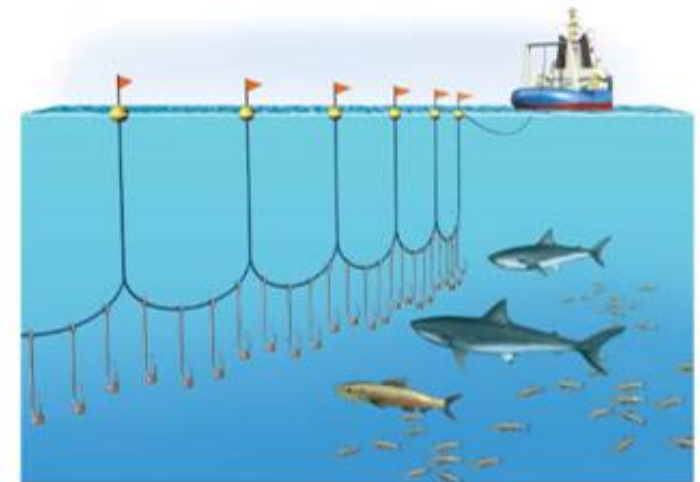
How will increased fishing pressure on forage fish species affect other populations?

Commercial Fishing Methods

- Fleets of enormous factory fishing vessels increase the reach and impacts of modern fishing beyond anything in the past.
 - Travel further and stay out longer by processing and freezing their catch on board (floating factories).
- **Long-line fishing:** extremely long lines (up to 30 miles) of several thousand baited hooks.
 - Mostly used to catch higher trophic level species (tuna, swordfish).
 - Occasionally **bycatch** of non-target species (turtles, dolphin, sharks, seabirds)
- **Drift nets:** transparent nylon nets that hang vertically from floats and drift in the current.
 - Used for schooling species that traverse open waters (herring, sardines, mackerel, shrimp)
 - Severe bycatch of turtles, dolphins, seals and a common source of **ghost fishing**, when damaged, tangled, or discarded nets are abandoned in the ocean.



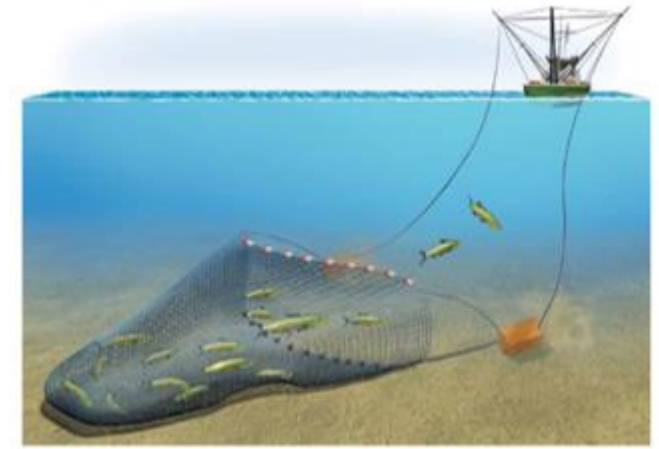
(a) Driftnetting



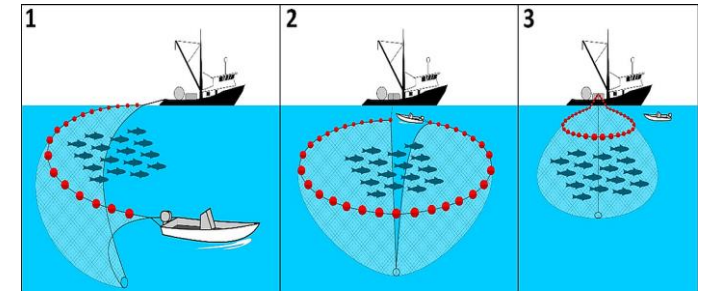
(b) Longlining

Commercial Fishing Methods

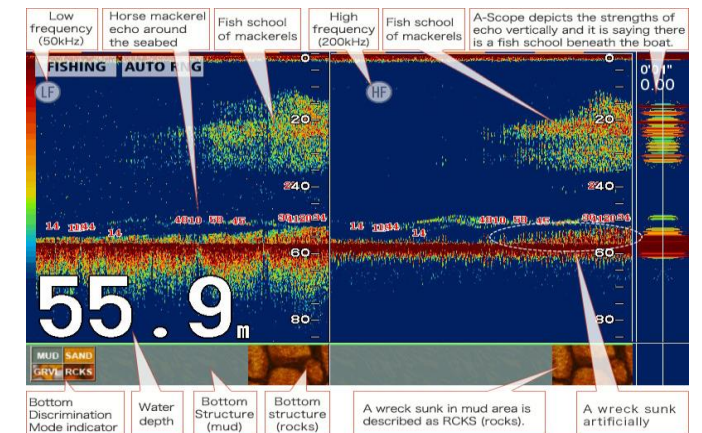
- **Trawling:** Cone Shaped nets dragged behind a moving ship. Bottom trawling adds weights to the nets to trawl for benthic species.
 - Often used for benthic species such as scallops, crab, and flounder.
 - Heavy bycatch of resting turtles, some dolphins and occasionally, pilot whales.
 - Bottom trawling is destructive to seafloor habitat (reefs especially)
- **Purse Sein:** a large wall of netting deployed around an entire area or school of fish. The seine has floats along the top line with a lead line that can be pulled in, closing the net on the bottom.
 - Used for schooling pelagic (open water) species of all species and squid
 - Bycatch of turtles, dolphin, and even Humpback whales
- **Sonar:** Used to detect the presence of fish by bouncing sound waves off of objects and mapping the return of the sound waves to a sensor.
 - Can disrupt communication among migrating whales.



(c) Bottom-trawling

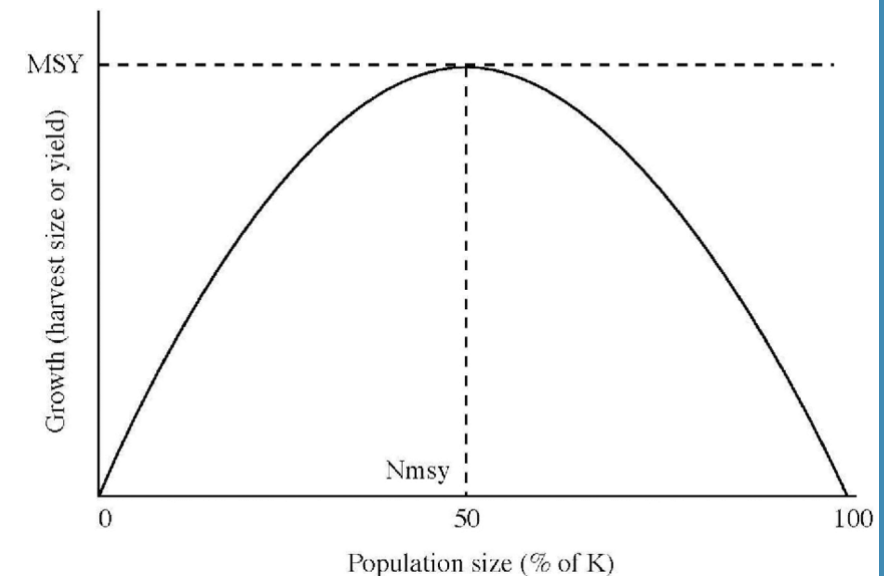
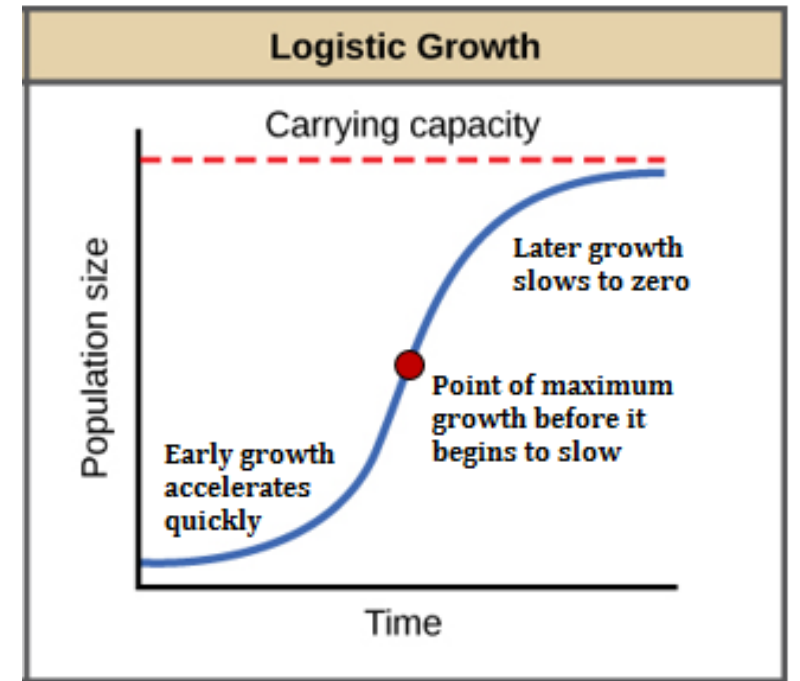


Purse Sein



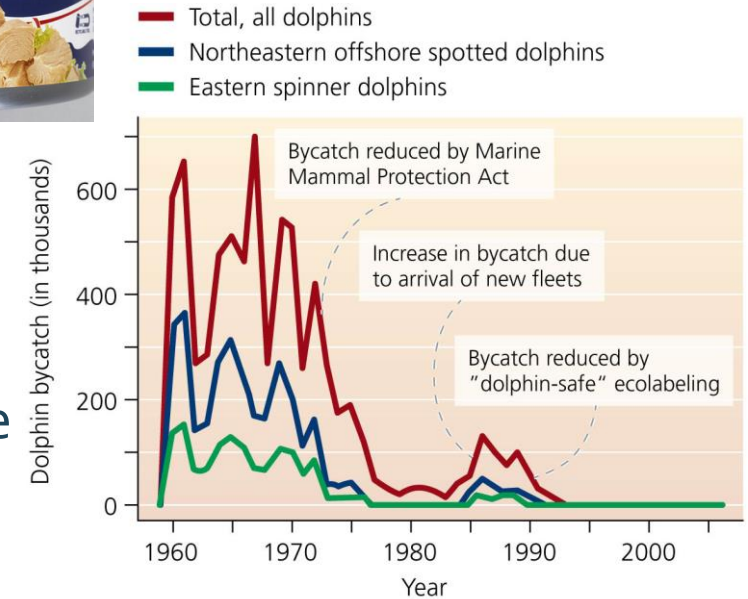
Addressing Overfishing

- Set limits on numbers of fish caught according to the **Maximum Sustainable Yield** of individual species.
 - Based on estimates of population **carrying capacity** and **logistic growth** of the population.
- Set limits on the size of individual fish caught and monitor the **age structure** of commercial fish populations.
 - Populations dominated by smaller / younger fish is an early warning of overfishing.
- Monitor the **catch per unit effort** of the fishing fleet, not just the number of fish caught.
 - Commercial fisherman will fish until they catch their limit or the season ends. If catching the limit is taking longer, populations are likely declining.
- Establish **Marine Protected Areas** and **Marine Reserves**.
 - Protected areas allow populations to recover with less fishing pressure.
 - Overflow of population from preserves into surrounding waters can enhance local fisheries.



Addressing Bycatch

- Improve fishing technologies and regulations
 - Use of Turtle Excluding Devices (TED's) on trawl nets.
 - Use of flags on long line floats to scare away and deter sea birds
 - Fishermen in U.S. waters of the pacific must use small water craft while hauling in purse seines to assist with freeing non-target organisms (mainly dolphins).
 - Drift nets are now banned in international waters, due to excessive bycatch and ghost fishing.
 - Still used in national waters off the coast of California and in other regions of the world.
 - Limits to the use of sonar (location of use and power of the unit)
- “Eco-labeling”
 - label seafood products to help consumers recognize and choose more sustainable seafood choices.
 - “Dolphin Safe Tuna”
- Enforcement of existing laws and international treaties.
 - Marine Mammal Protection Act, Endangered Species act (ESA), Convention on the International Trade of Endangered Species (CITES)



Aquaculture

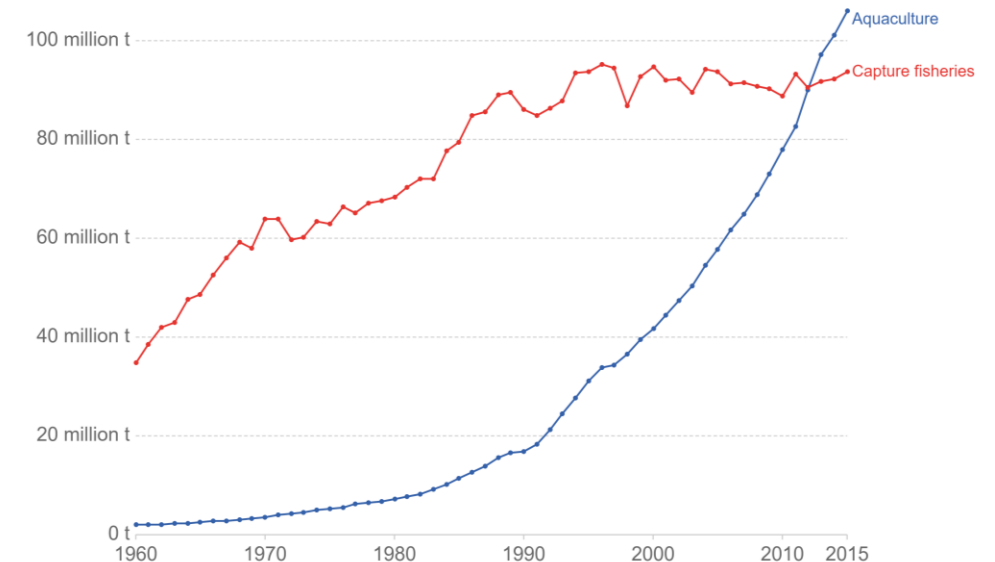
- With the collapse of many commercial fisheries, and the rising demand for seafood, the use of aquaculture is increasing rapidly.
- **Aquaculture** is the farming aquatic organisms (marine or freshwater) in large pens or other structures within natural bodies of water.
 - Fish, shellfish, mollusks, crustaceans, and aquatic plants
- Aquaculture has increased rapidly (mostly in eastern Asia, where China is the world leader) and now surpassed the amount of fish produced by wild fisheries.
- Highly efficient compared to terrestrial livestock for producing calories of protein per unit of space.
- Is safer and less dependent on fossil fuels than wild fisheries.



Seafood production: wild fish catch vs aquaculture, World, 1960 to 2015

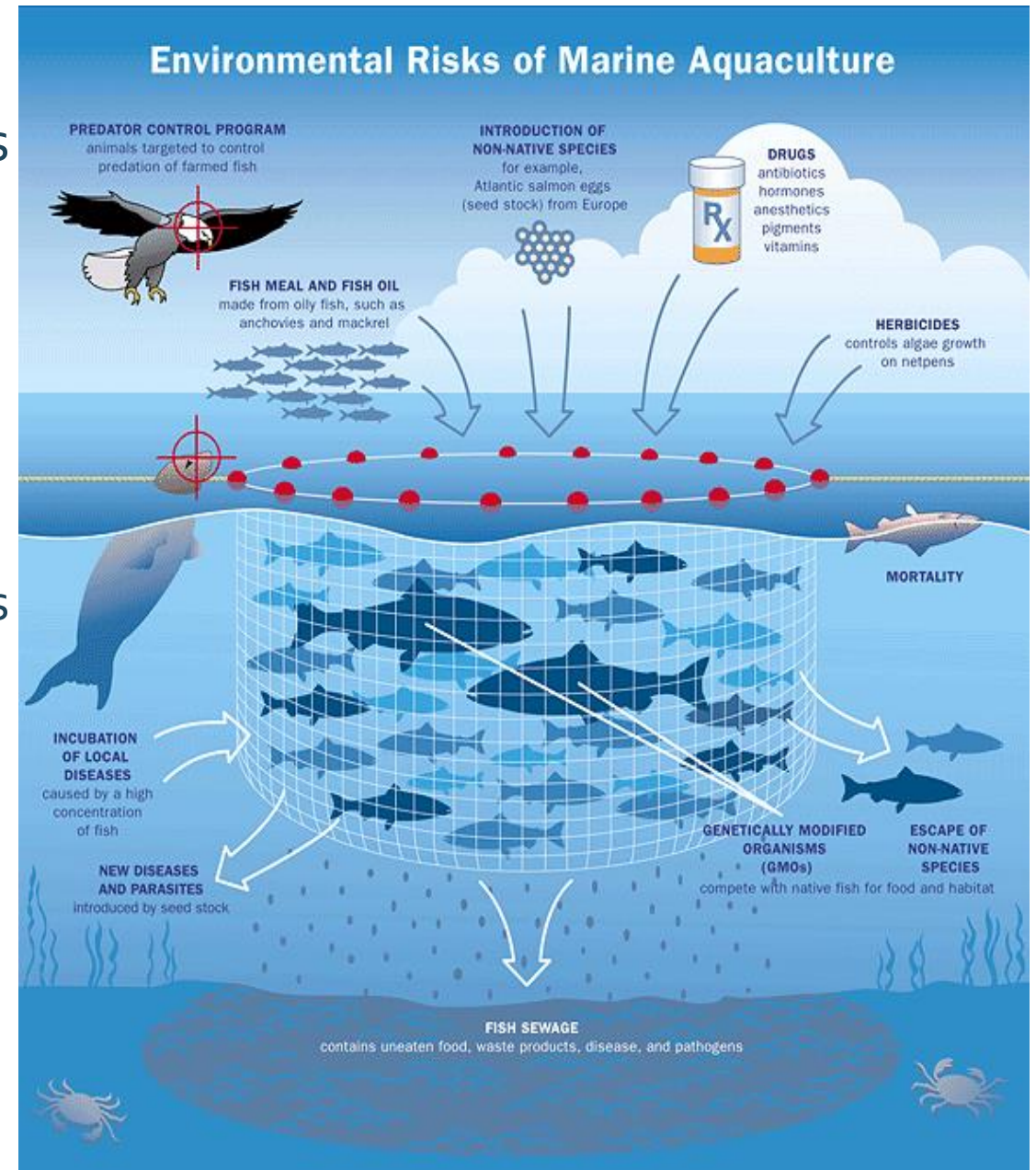
Aquaculture is the farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants. Capture fishery production is the volume of wild fish catches landed for all commercial, industrial, recreational and subsistence purposes.

Our World
in Data



Drawbacks of Aquaculture

- As in terrestrial agriculture, when large numbers of animals are kept at high population densities, problems can arise.
 - Waste from organisms and uneaten food pellets can pollute waterways (eutrophication; algal blooms and hypoxic conditions).
 - The density of organisms in pens means that disease and parasites are more likely.
 - Bacterial diseases are controlled with antibiotics and antibiotic resistance may result.
 - Medications can contaminate waterways.
 - Disease may spread from farmed fish to wild populations.
 - Farmed organisms may escape, especially if pens are damaged by storms.
 - May introduce non-native species (competition) or GMO's (interbreeding and loss of genetic diversity to ecosystem, negatively impacting wild populations).

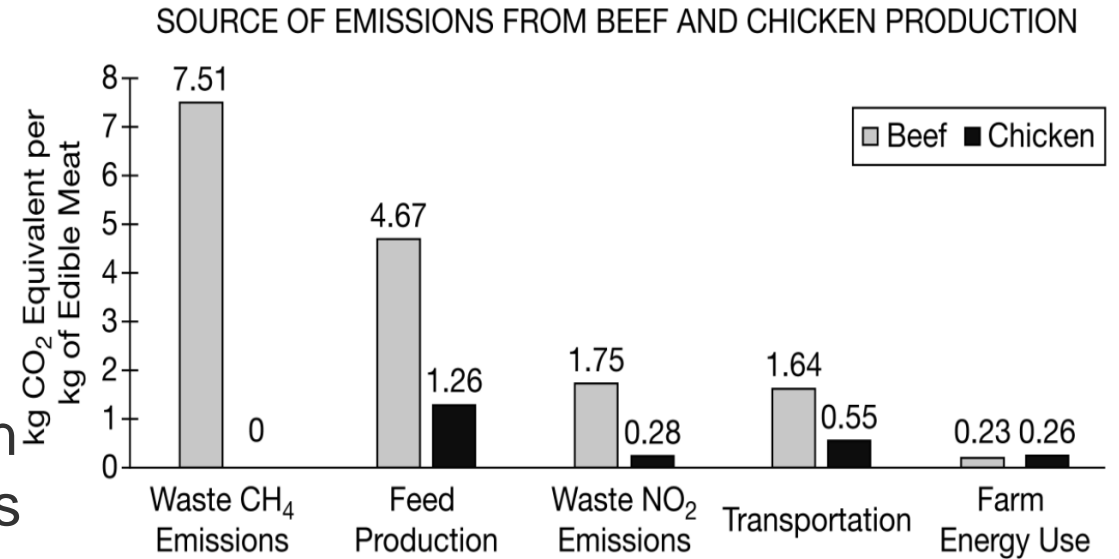


Video Resources

- Fishing
 - https://www.youtube.com/watch?v=rkpnS8xllbs&feature=emb_logo

Topic Questions

1. Carbon dioxide equivalent (CO_2e) is used to compare contributions to climate change of various greenhouse gases. A study at a farm calculated the carbon dioxide equivalent for different production stages for beef and chicken production. Which of the following statements is best supported by the data in the graph?



- Producing food for beef and chicken emits a total of 4.67kg CO_2e per kg of edible meat, released during transport and processing of animal feed.
- The carbon dioxide equivalent for farm energy use by chickens is the greatest source of emissions, because the 24 hours of lighting that chickens require to grow uses a lot of electricity.
- Raising beef contributes more to greenhouse gases than raising chickens does, primarily as a result of fermentation in cows' digestive tracts, which releases methane gas.
- Chicken manure does not emit any greenhouse gases, because chickens have unique symbiotic bacteria in their digestive systems.

Topic Questions

	Farm A	Farm B
Animal waste concerns	Compost manure reused on site for fertilizer	Manure stored in lagoons until liquefied and sprayed on crops
Average days in stable in any 12-month period	0 days	45 days
Antibiotic usages	Only for animals that are ill	Routinely provided to prevent spread of disease

Based on the data provided, which of the following descriptions best identifies the types of farms that are being compared?

- A** Farm A is a free-pasture farm for cattle, whereas Farm B is a free-range farm for poultry.
- B** Farm A is a concentrated animal feedlot for beef production, whereas Farm B is a cage-free farm for poultry.
- C** Farm A is a grass-fed pasture for beef production, whereas Farm B is a traditional concentrated animal feedlot for cattle.
- D** Farm A is a cage-free farm for poultry, whereas Farm B is an industrial poultry farm.

Topic Questions

The harvesting of livestock for meat consumption affects the planet in various ways. Approximately 25% of the land area on Earth is used for raising livestock. One-third of all water used in meat production goes toward producing beef, and the demand for beef is projected to increase by 95% by 2050. The graph below shows the average meat consumption per capita from 2010 to 2012 and the forecasted meat consumption for 2022 for five different countries.

Which of the following claims is best supported by the data in the graph?

- A** As the demand for chicken increases and the demand for beef decreases, changes in meat production will decrease the demand on global water supplies.
- B** Meat consumption per capita will decrease in India between 2012 and 2022 because individuals in that country have a primarily vegetarian diet.
- C** Global meat consumption per capita will increase in all five countries between 2012 and 2022 as the countries move through the demographic transition and
- D** The use of growth hormones and antibiotics will allow for an increased yield in meat production in all five countries by 2022.

2010–2012 (AVERAGE) AND 2022 (FORECASTED) MEAT CONSUMPTION PER CAPITA (KG) FOR FIVE DIFFERENT COUNTRIES

