DP IB Environmental Systems & Societies (ESS): SL

Your notes

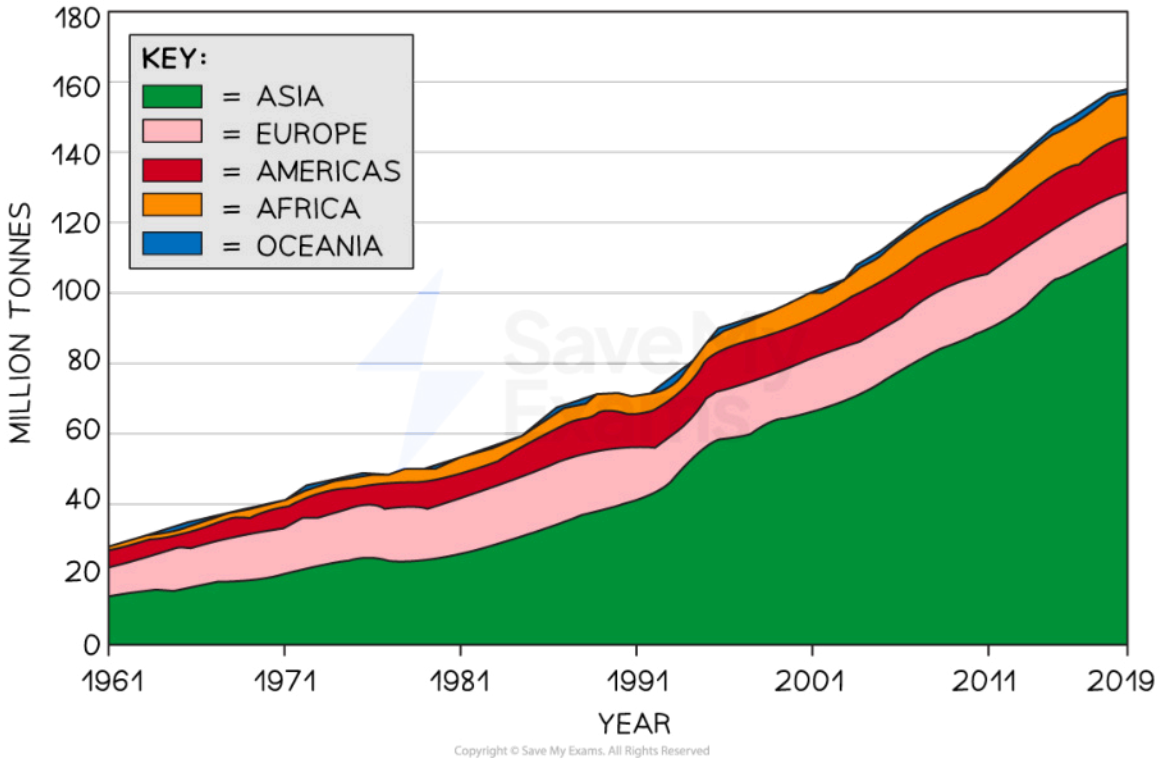
Aquatic Food Production Systems

Contents

Demand for Aquatic Food Production

Your notes

Demand for Aquatic Food Resources



Global aquatic food consumption

- The demand for aquatic food resources is experiencing a significant **increase** due to the combined effects of a **growing human population** and **dietary changes**
- As populations expand and economies develop, there is a higher demand for seafood products to meet nutritional needs and culinary preferences
- The main factors behind the increase in demand for aquatic food resources are as follows:

1. Growing Human Population

- The global population has been steadily increasing over the years, resulting in a larger consumer base for aquatic food resources

2. Changing Dietary Patterns

- As countries undergo economic growth, there is often a shift in dietary patterns towards increased consumption of protein-rich foods, including seafood

3. Nutritional Benefits of Seafood

- Seafood is recognised as a valuable source of essential **nutrients**, such as omega-3 fatty acids, vitamins, and minerals, which contribute to **human health** and well-being

4. Urbanisation and the rising middle class

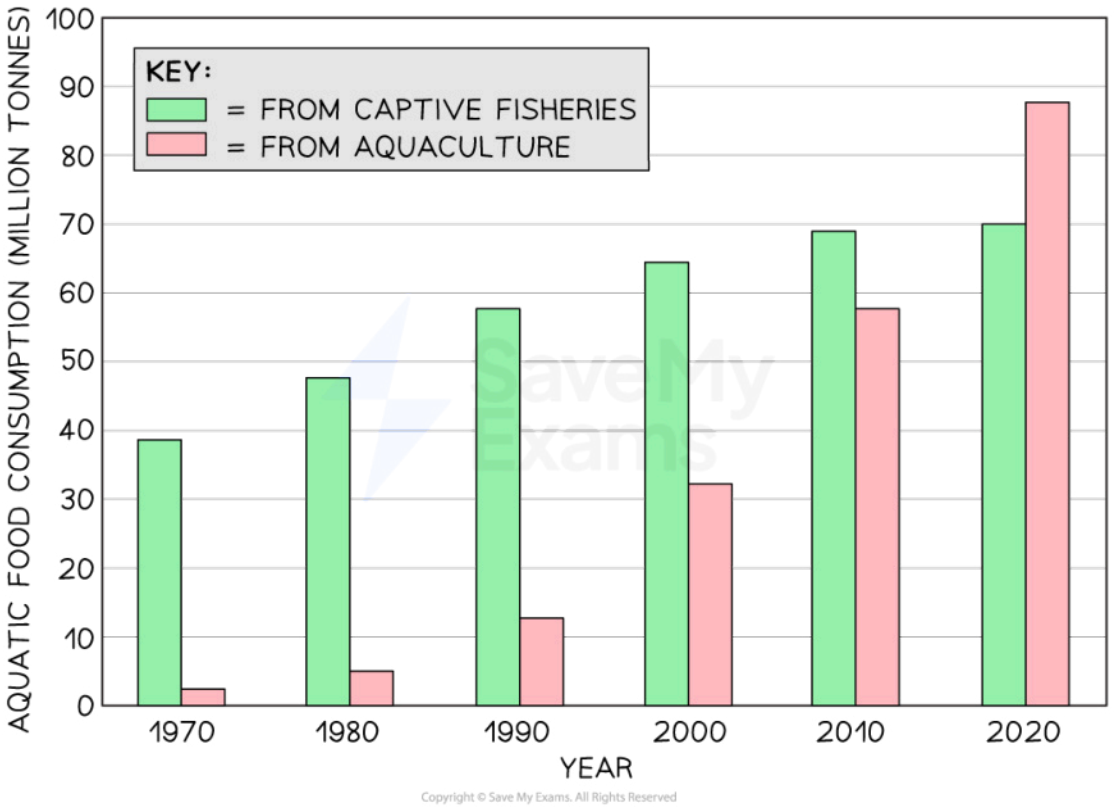
- Urbanisation and the emergence of a middle class in many regions have led to changes in dietary preferences, with an increased demand for diverse and higher-value food options, including seafood

5. Global trade and supply chains

- Advances in transportation and the expansion of global trade networks have made it easier to **import** and **export** seafood products, increasing their availability to communities

6. Aquaculture production

- Aquaculture, the farming of aquatic organisms, has experienced significant growth to meet the rising demand for seafood



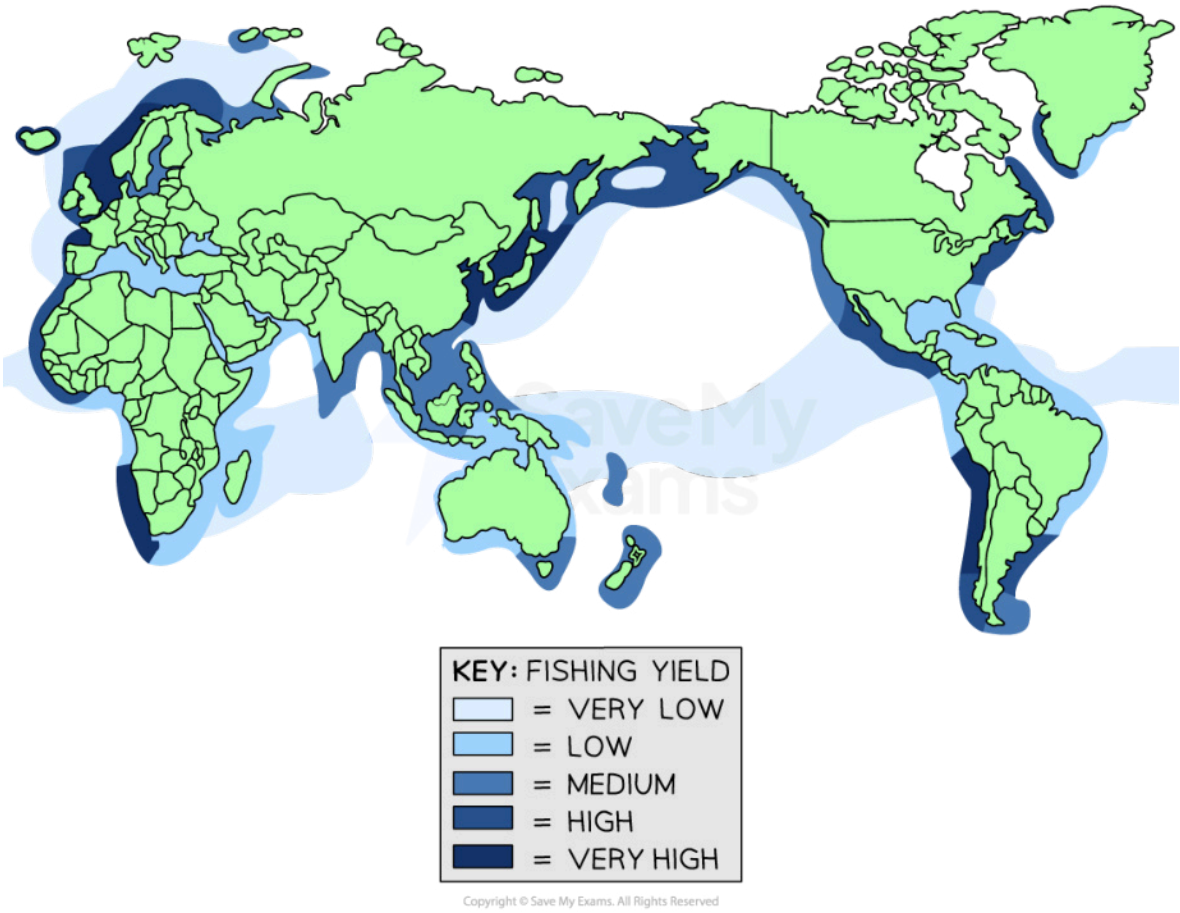
Your notes

The relative contribution of aquaculture and capture fisheries

Photosynthesis and Aquatic Food Webs

Your notes

- **Photosynthesis** by **phytoplankton** forms the foundation of marine food webs, supporting a highly diverse range of organisms within marine ecosystems
  - Phytoplankton utilise sunlight, carbon dioxide and nutrients to produce organic matter through photosynthesis
  - The **organic matter** produced by phytoplankton serves as a vital **food source** for various marine organisms, including zooplankton, invertebrates and small fish
  - The energy derived from phytoplankton is then transferred up the food chain, sustaining larger predators such as marine mammals, birds, and humans



Areas of high marine productivity

- Phytoplankton **productivity** is highest near the **coast** or in **shallow seas** due to specific environmental factors:
  - Upwellings occur when wind-driven movements bring cold, **nutrient-rich** water from the deeper ocean layers to the surface
  - Upwelling zones promote phytoplankton growth by providing an abundance of nutrients like nitrogen, phosphorus, and iron that are essential for their **photosynthetic activity**
  - Nutrient enrichment of surface waters in these regions stimulates the growth of phytoplankton, leading to **increased productivity and biomass**
  - The high productivity near the coast and in shallow seas create ideal conditions for the development of diverse food webs
  - In addition to upwellings, other factors such as **coastal runoff** and mixing of **nutrient-rich freshwater** also contribute to the enrichment of surface waters, supporting phytoplankton growth and food web complexity
  - These regions serve as crucial hotspots for marine biodiversity and play a significant role in the overall health and functioning of marine ecosystems


Your notes

Worked Example

Give an example of an area of high marine productivity caused by upwellings and nutrient enrichment of surface waters

Answer

The coast of Peru and Chile is an excellent example of how upwellings and nutrient enrichment of surface waters support high productivity and diverse food webs. This region experiences one of the most productive marine ecosystems in the world, known as the Humboldt Current System or the Peru-Chile Current System.

The coast of Peru and Chile is influenced by the Humboldt Current, a cold, nutrient-rich ocean current that flows northward along the western coast of South America. The prevailing winds in this region, such as the trade winds and the southward-flowing Antarctic Circumpolar Current, drive coastal upwelling. Upwelling brings deep, nutrient-rich waters to the surface, providing an abundant supply of nutrients like nitrates, phosphates, and silicates that are essential for phytoplankton growth.

The nutrient-rich waters of the Humboldt Current System support massive phytoplankton blooms, particularly of diatoms and other fast-growing algae. These phytoplankton populations experience rapid growth due to the availability of nutrients and sunlight, leading to high rates of primary

productivity. The high primary productivity supports a diverse range of organisms throughout the food web.

Your notes

What is Aquaculture?

Your notes

Aquaculture

What is Aquaculture?

- Aquaculture, also known as fish farming or aquafarming, refers to the **cultivation** of aquatic organisms in **controlled environments** such as ponds, tanks, or ocean enclosures
- It involves the rearing, breeding, and harvesting of various species of fish, shellfish, algae, and other aquatic organisms for commercial, recreational, or conservation purposes
- Aquatic flora and fauna, both freshwater and marine, are harvested by humans through various methods to meet different needs and purposes.

Photo by Lucut Razvan on Unsplash

Fish farming is one example of aquaculture

Finfish and Shellfish

- Finfish such as salmon, tilapia, and catfish are commonly harvested through aquaculture
  - They are reared in ponds, cages, or tanks and fed a controlled diet until they reach market size
- Shellfish, including oysters, mussels, and clams, are cultivated in coastal areas or specialised farms
  - They are grown on submerged structures or suspended ropes, allowing them to filter feed and grow

Shrimp and Prawns

- Shrimp and prawn farming is prevalent in both freshwater and marine environments
  - Ponds or enclosed systems are used to cultivate these crustaceans
  - They are fed a formulated diet and managed until they reach harvestable size

Seaweed and Algae

- Ropes, nets, or floating structures are used to grow these aquatic plants in coastal or oceanic waters
  - Harvesting involves manually cutting or collecting mature seaweed or algae biomass from the cultivation structures

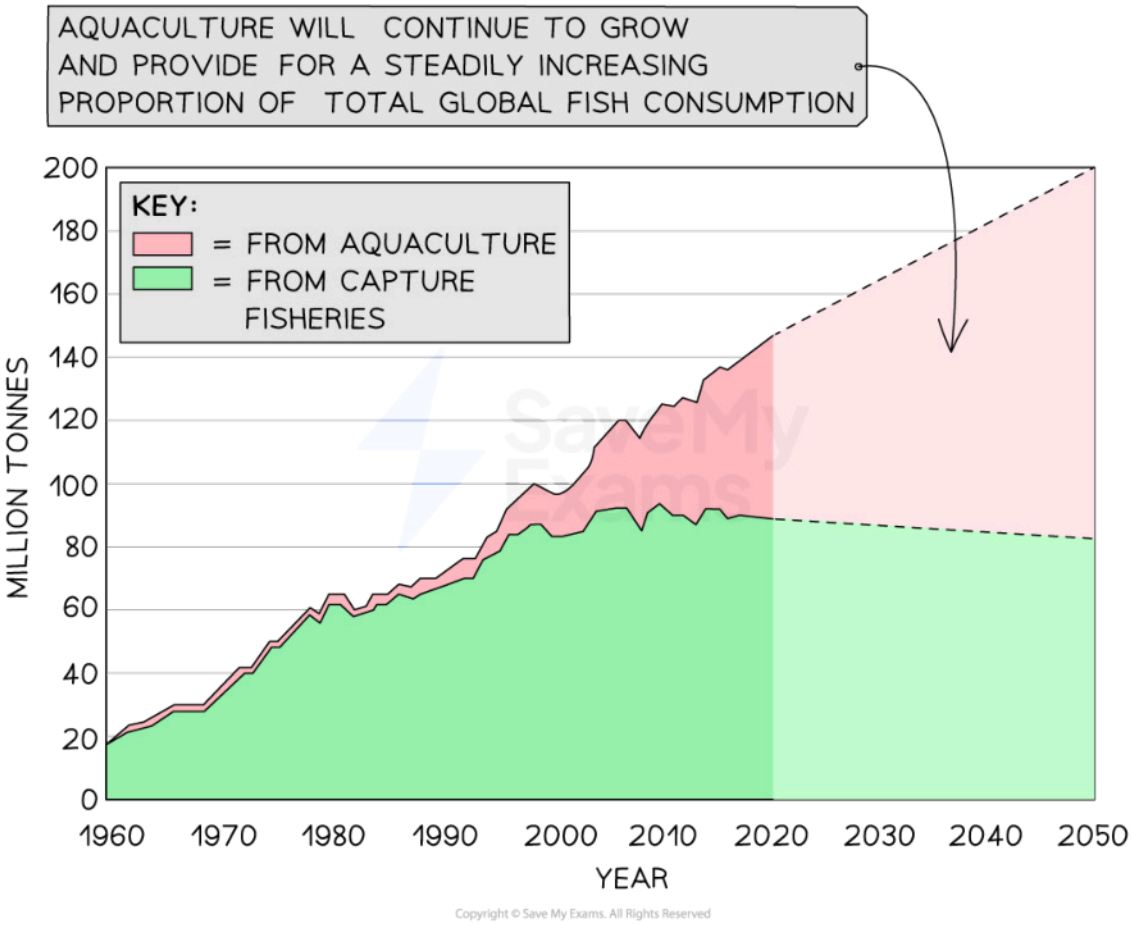
Molluscs and Bivalves

- Molluscs such as scallops, abalone, and snails, as well as bivalves like mussels and clams, are often harvested from natural or artificial beds in both freshwater and marine environments
  - They are often collected using handpicking, rakes, or dredges, depending on the species and harvesting location


Your notes

The Growth of Aquaculture

Your notes



The growth of global aquaculture

- Aquaculture plays a crucial role in **meeting** the growing **demand** for seafood while **reducing pressure** on **wild fish populations**
- Aquaculture has experienced significant growth to meet the increasing global demand for seafood, which is driven by population growth, changing dietary preferences, and rising incomes
- By cultivating fish, shellfish, and other aquatic organisms through aquaculture, the pressure on wild fish populations can be reduced, allowing them to **recover** and the **ecological balance** of these marine ecosystems to be **restored**
- Aquaculture has the potential to provide a reliable and sustainable source of seafood, helping to meet the protein needs of a growing population, whilst also minimising the impact on wild fish stocks

1. Providing additional food resources

- Aquaculture contributes to global food security by providing an additional source of nutritious food resources
- Cultivating fish and shellfish through aquaculture offers a **consistent supply** of **protein-rich** seafood, which can help address **nutritional deficiencies** and improve human health in many parts of the world
- The controlled environments of aquaculture systems allow for efficient production and reduced waste, making it an important method for increasing food production

2. Supporting economic development

- Aquaculture has emerged as a significant sector in the global economy, generating employment opportunities, income, and economic growth
- It provides livelihoods for millions of people, particularly in coastal and rural communities, where fishing and aquaculture activities are integral to the **local economy**
- Aquaculture encourages trade and investments, contributing to the overall development and prosperity of regions and whole countries


Your notes

The potential value of aquaculture for providing food for future generations

Your notes

Image from the NOAA: [1], Public domain, via Wikimedia Commons

A shrimp hatchery attempts to provide a sustainable source of seafood

- The growth of aquaculture is expected to continue in the coming years due to several factors:
  - **Rising global demand for seafood** - the growing population, urbanisation, and changing dietary preferences drive the need for increased seafood production
  - **Technological advancements** - ongoing research and technological developments in aquaculture practices, breeding techniques, feed formulations, and disease management are enhancing production efficiency and sustainability
  - **Environmental considerations** - aquaculture is evolving towards more environmentally friendly and sustainable practices, addressing concerns such as waste management, habitat impacts, and ecosystem interactions
  - **Innovation and diversification** - the development of new species for aquaculture, such as high-value finfish and seaweed, opens up opportunities for market expansion and product

diversification
    - **Policy support** - Governments and international organisations are promoting and investing in aquaculture development to address food security, reduce pressure on wild fish stocks, and support economic growth
- Aquaculture has already grown significantly in order to meet the growing global demand for seafood, providing additional food resources, and supporting economic development in many countries and communities around the world
- With continued advancements and technological innovations, aquaculture is expected to play an increasingly vital role in the global food system, contributing to food security, economic prosperity, and potentially even long-term environmental sustainability


Your notes

Issues in Aquaculture

- Issues around aquaculture include:
  - Habitat loss
  - Pollution (with feed, antifouling agents, antibiotics and other medicines added to fish pens)
  - Spread of diseases
  - Escaped species (sometimes involving genetically modified organisms)
  - Ethical Issues and biorights
  - Rights of indigenous cultures

Issues in Aquaculture

Issue	Description
Habitat loss	▪ Aquaculture facilities often require the **conversion of natural habitats** such as wetlands, mangroves, or coastal areas into fish farms ▪ These habitats are **cleared** or **modified** to create suitable spaces for aquaculture operations ▪ This habitat loss can have negative impacts on biodiversity, ecosystem functions, and the livelihood of local communities
Pollution	▪ **Excess nutrients** from uneaten feed and fish waste can leach into the surrounding water bodies, leading to **eutrophication**, algal blooms, and **oxygen depletion** ▪ Some feed formulations may contain **additives** such as growth enhancers or colourants that can potentially negatively impact water quality ▪ Powerful chemicals known as **antifouling agents** are used to prevent the growth of marine organisms (e.g. mussels and barnacles) on aquaculture infrastructure - these biocides can leach into the surrounding water, potentially causing harm to marine life ▪ To prevent and treat diseases, aquaculture operations may use **antibiotics** and **other medicines**, which can enter the water through waste discharges and pose risks to aquatic organisms and contribute to antibiotic resistance

Spread of diseases	▪ The **high density** of fish in aquaculture facilities can facilitate the spread of diseases among farmed fish, leading to increased disease risks and the need for **disease management strategies** ▪ If proper **biosecurity measures** are not in place, pathogens can also spread from aquaculture facilities to **wild fish populations**, impacting their health and survival
Escaped species	▪ Escape of farmed fish from aquaculture facilities can lead to **genetic interactions** with **wild populations**, potentially impacting wild species through competition, interbreeding, or transmission of genetic diseases ▪ Some aquaculture operations involve the use of **genetically modified fish**, raising concerns about potential ecological impacts and ethical considerations if these fish breed with wild populations
Ethical Issues and biorights	▪ Aquaculture raises ethical questions regarding the **treatment** and **welfare** of farmed animals, particularly in **intensive** farming systems ▪ Concerns centre around the **confinement** and **stress** experienced by farmed species, the use of antibiotics and growth enhancers, and the overall quality of life for the animals ▪ The concept of biorights, which advocates for the inherent rights of living organisms to exist and **thrive,** is often discussed in the context of aquaculture ethics
Rights of indigenous cultures	▪ Aquaculture activities may conflict with the rights and interests of indigenous cultures and communities that rely on aquatic resources for their livelihoods and cultural practices ▪ The establishment of aquaculture facilities or the introduction of non-native species can impact **traditional fishing grounds**, disrupt customary practices, and potentially erode indigenous rights and cultural heritage

Your notes

- In addition, issues in aquaculture can often arise regarding **international conservation legislation**
  - Aquaculture must comply with international conservation legislation and regulations to ensure the sustainable use of resources and to protect biodiversity
  - International frameworks such as the Convention on International Trade in Endangered Species (**CITES**) and the Convention on Biological Diversity (**CBD**) have implications for aquaculture operations involving endangered or protected species
  - Compliance with these regulations helps **prevent** the **exploitation** of threatened species, maintain ecological balance, and ensure the long-term viability of aquaculture practices

- It is essential for the aquaculture industry, policymakers, and stakeholders to engage in dialogue and address all the issues outlined above through ethical frameworks, consultation processes, and responsible governance
- Balancing environmental sustainability, animal welfare, cultural rights, and legal obligations is crucial to maintaining an equitable and socially responsible aquaculture sector


Your notes

Unsustainable Fishing Practices

- Developments in fishing equipment and changes to fishing methods have led to dwindling fish stocks and damage to habitats
- **Fish stocks** (the populations of fish that we catch for food) in the oceans are **declining**
- This is mainly due to **overfishing**
- This could potentially result in:
  - Some species of fish **completely disappearing in certain areas** or even going extinct (e.g. we are at risk of losing cod completely in the north-west Atlantic)
  - Ocean **food chains** being **disrupted**, affecting many other aquatic species
  - **Fewer fish for human consumption** – this would be especially problematic for populations that rely on fish as a main source of food
- For these reasons, it is important to maintain fish stocks at a level where **breeding continues**
- **Sustainable fisheries** are required to achieve this – these are fisheries in which the overall **population size** of fish species **does not decrease** as the number of fish caught in a given time period (e.g. a year) does not exceed the number of new fish that are born
- Sustainable fishing means:
  - Leaving **enough fish** in the ocean
  - **Protecting habitats** and marine food webs that fish rely on
  - Human communities that catch and process fish can **maintain their livelihoods**

Measures to make commercial fishing more sustainable

Mitigating Unsustainable Exploitation

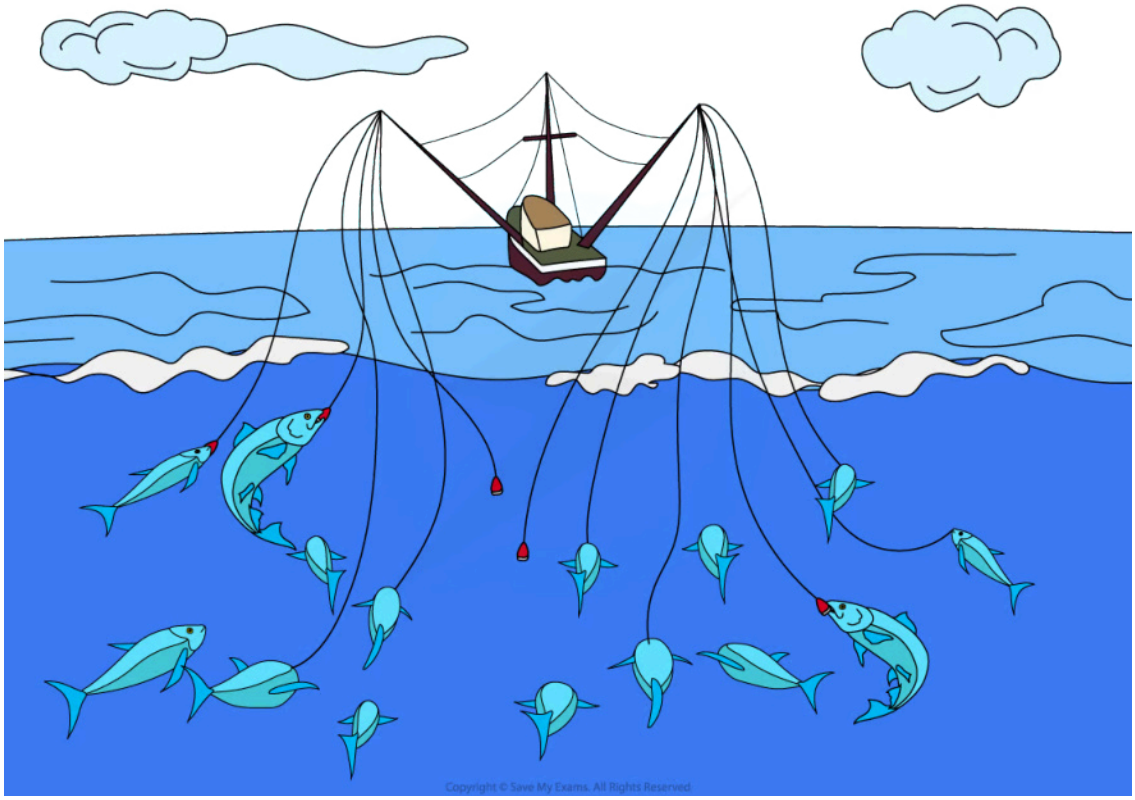
- Unsustainable exploitation of aquatic systems can be mitigated at a variety of levels (international, national, local and individual) through policy, legislation and changes in consumer behaviour
- For example, **control of net size** and the introduction of **fishing quotas** play important roles in the conservation of fish stocks at a sustainable level
- **Increasing** the **size of gaps** in fishing nets can help in two main ways:


Your notes

- **Fewer unwanted species** (that are often simply discarded) will be caught and killed, as they can **escape through larger net gaps** (as long as they are smaller than the species being caught – the accidental capture and killing of larger species is still a problem that is reducing the populations of these species)
- **Juvenile fish** of the fish species being caught can **escape through larger net gaps**, meaning they can **reach breeding age** and have **offspring** before they are caught and killed. This ensures the population of the fish species being caught can be **replenished**

- In addition to tighter controls on net size, **fishing quotas** that **limit the number and size** of particular fish species that can be caught in a given area have been introduced by many countries to stop species becoming overfished
- Governmental regulation can be enforced by:
  - Establishing **fishing quotas**
  - Agreeing areas of the ocean where fishing is **banned** (e.g. spawning grounds) and **permitted** (e.g. within a country's territorial waters)
  - Regulating **mesh size** of nets (to allow undersized/juvenile fish to escape)
  - Limiting the **size of the fishing fleet** by issuing licenses
  - **Inspecting the catch** as a fishing boat returns to port
  - **Banning** certain practices e.g. **gillnets** (static nets that catch anything that swims by, and the fish struggle and die in distress)
  - Promoting sustainable practices such as **trolling** (different to **trawling**) that reduces **bycatch**

Your notes



Trolling uses hook-and-line and reduces bycatch and damage to the seabed

- Nevertheless, a lot of commercial fishing is still carried out **illegally**
  - There is an extremely **large area** of ocean for authorities to patrol
  - High demand and profit potential have made fish poachers more daring and **willing to break the law**