Fish Feeding:
10-Natural food and its estimation

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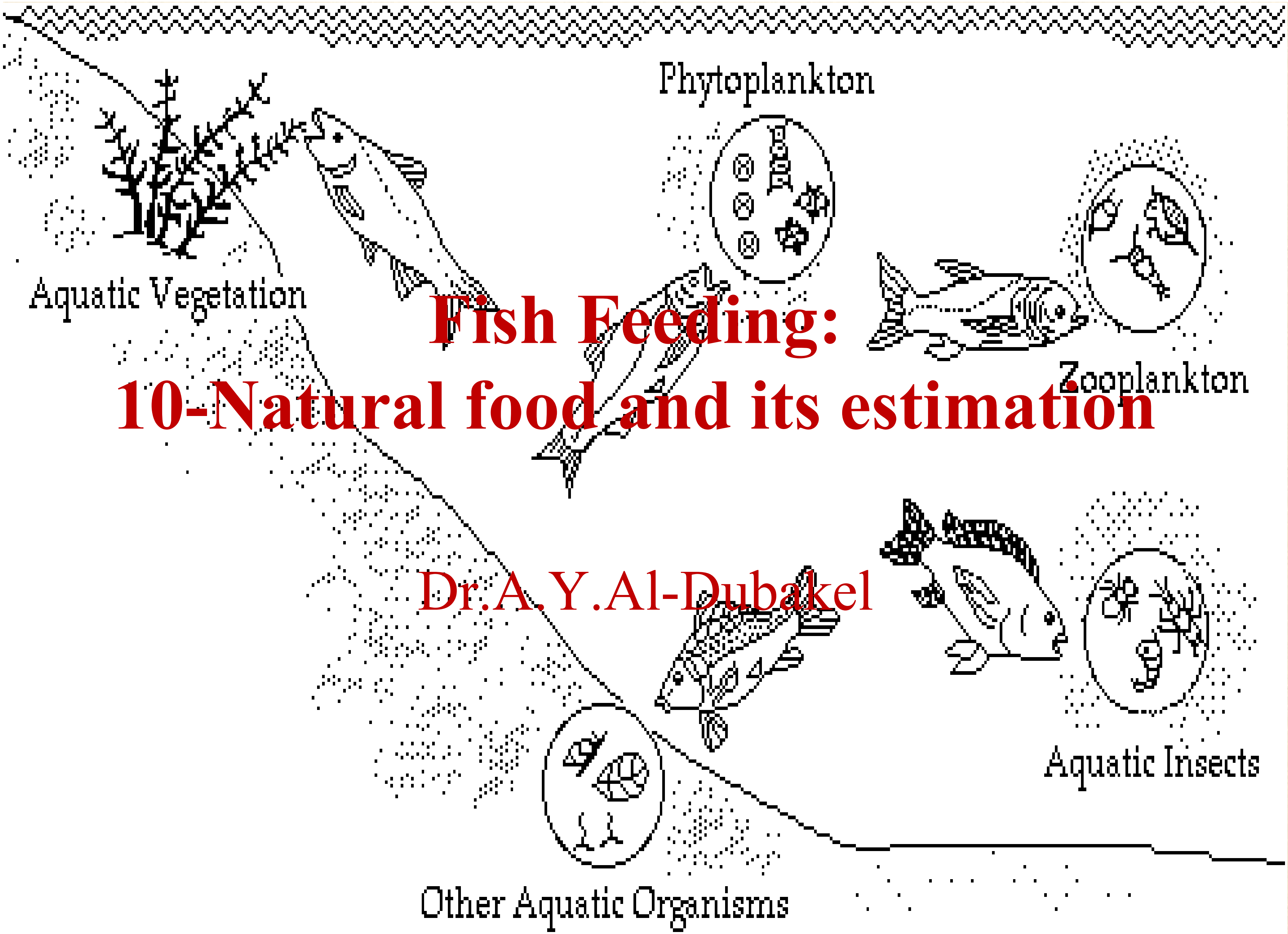


Fish Feeding – Syllabus

1- Introduction

2- Fish Nutritional Needs

3- Feeding and Digestion

4- Digestive Processes

5- Control and Regulation of Digestion

6- Nutrient Metabolism

7- Digestibility

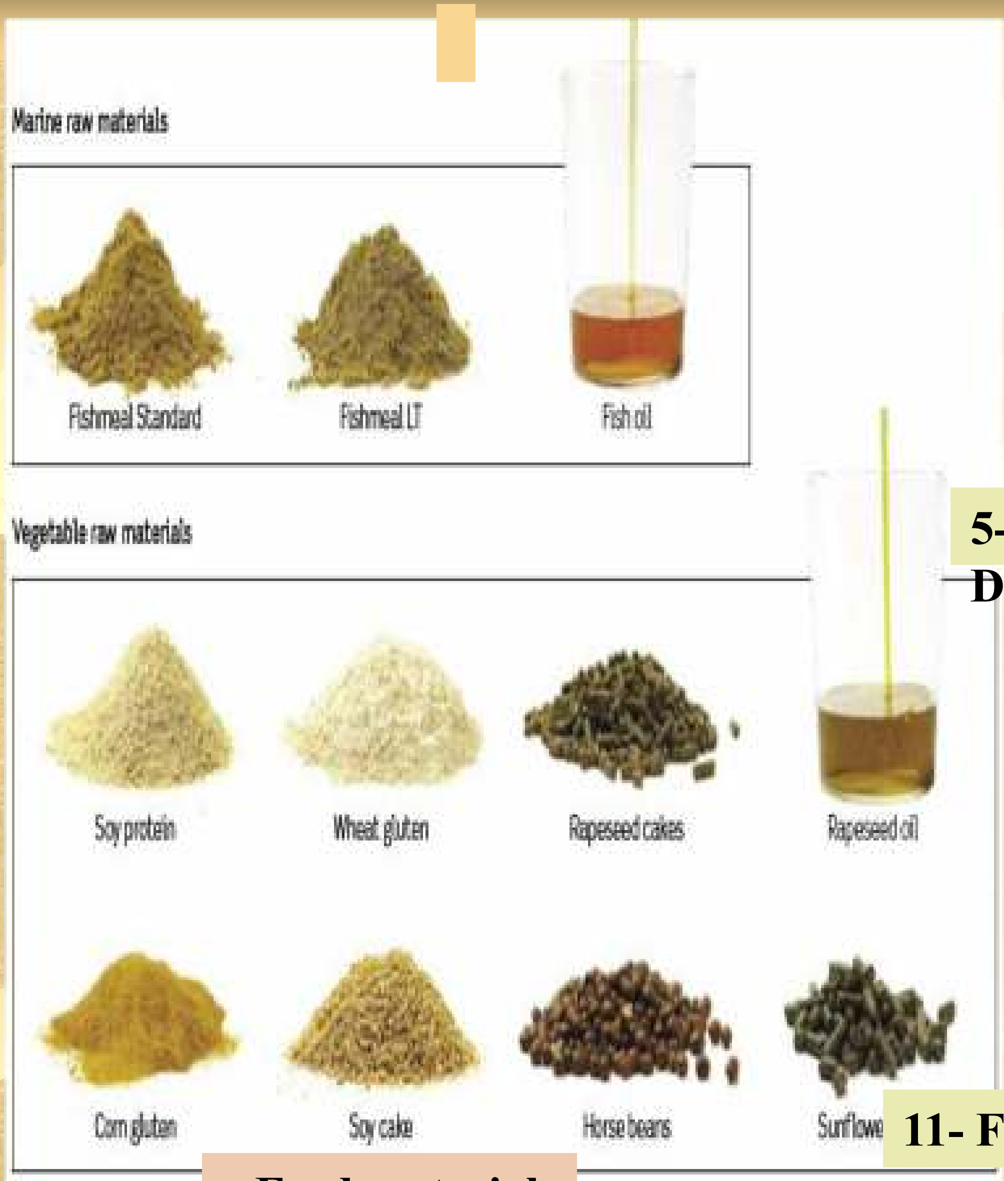
8- Nutrition Physiology

9- Anatomy and Diet

10- Sensory Organs

11- Food Capture Structures and Organs

12- Nutritional Physiology in Larval Fish



Feed materials

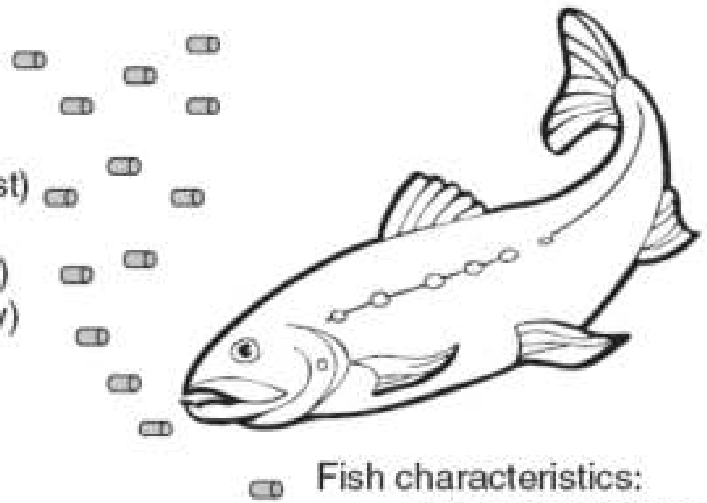
Report on Fish feedin

Ref.(Halver,2002)&Hepher,1988)

Biotic and abiotic factors that interact to influence feeding behavior and feed intake in farmed fish

Feed availability (how much, where and when?):
- Amount provided
- Timing of presentation (meal frequency, time of day)
- Distribution (dispersed or point source)

Feed characteristics:
- Appearance of feed
  - Size and shape
  - Colour (background contrast)
  - Movement and sinking rate
- Chemical properties (smell, taste)
- Texture (hard or soft, moist or dry)



Environmental conditions:
- Temperature
- Salinity
- Light
  - Photoperiod (hours of light each day)
  - Light intensity
  - 'Natural' or 'artificial' light (wavelengths)
- Water flow and currents
- Water quality
  - Oxygen concentration
  - Metabolic wastes (ammonia, carbon dioxide)
  - Pollutants
- Tank design and colour
- Outside disturbances (predators, human, etc.)

Fish characteristics:
- Life stage (larva, juvenile, adult)
- Health status
- Behavioural features
  - Schooling or solitary or territorial
  - Social rank and competitive ability
- Senses used when feeding
  - Vision
  - Chemical (smell, taste)
  - Tactile
- Feeding habits
  - Carnivore, omnivore, herbivore
  - Pelagic or benthic
  - Diurnal or nocturnal

Natural food and its estimation

The relationship between the density and the individual growth rate is not linear but a curved regression. Since yield per unit area is a product of the average individual growth rate and the number of fish per unit area (density), the effect of density on yield is also not a simple one. As long as the rate of increase in fish density is higher than the rate of decrease in individual growth rate, yield increases. When the decrease in growth rate exceeds the increase in fish density, yield decreases.

The optimum density is therefore that in which the fish utilize the natural food to give the highest possible yield per unit area. The determination of the optimum fish density in these cases requires a better knowledge of the amounts of available natural food in the pond, on the one hand, and the relationships between 1-the amount of food

Yield/area = Fish growth rate X No. fish/area (Density)

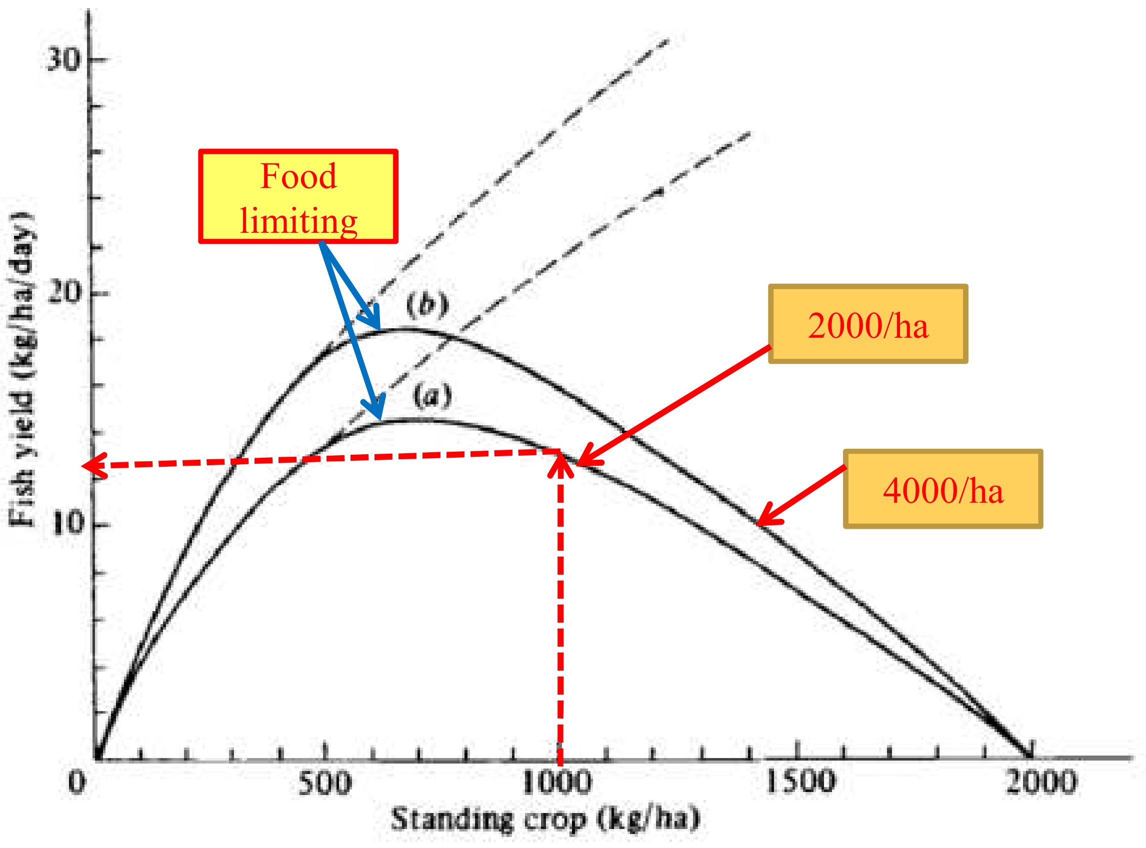
1- Yield/area = Fish growth rate < No. fish/area (Density)

1- Yield/area = Fish growth rate >No. fish/area (Density)

increase in fish density is higher than the rate of decrease in individual growth rate, yield increases.

the decrease in growth rate exceeds the increase in fish density, yield decreases.

Figure 36. The relationship between standing crop and yield per unit area for fish receiving sorghum in ponds stocked at two fish densities: (*a*) 2000/ha; (*b*) 4000/ha. Solid line gives calculated values based on actual average growth rates (Figure 22). Broken line gives extrapolated possible growth when food is not limiting according to equation (37) (from Hepher, 1978).

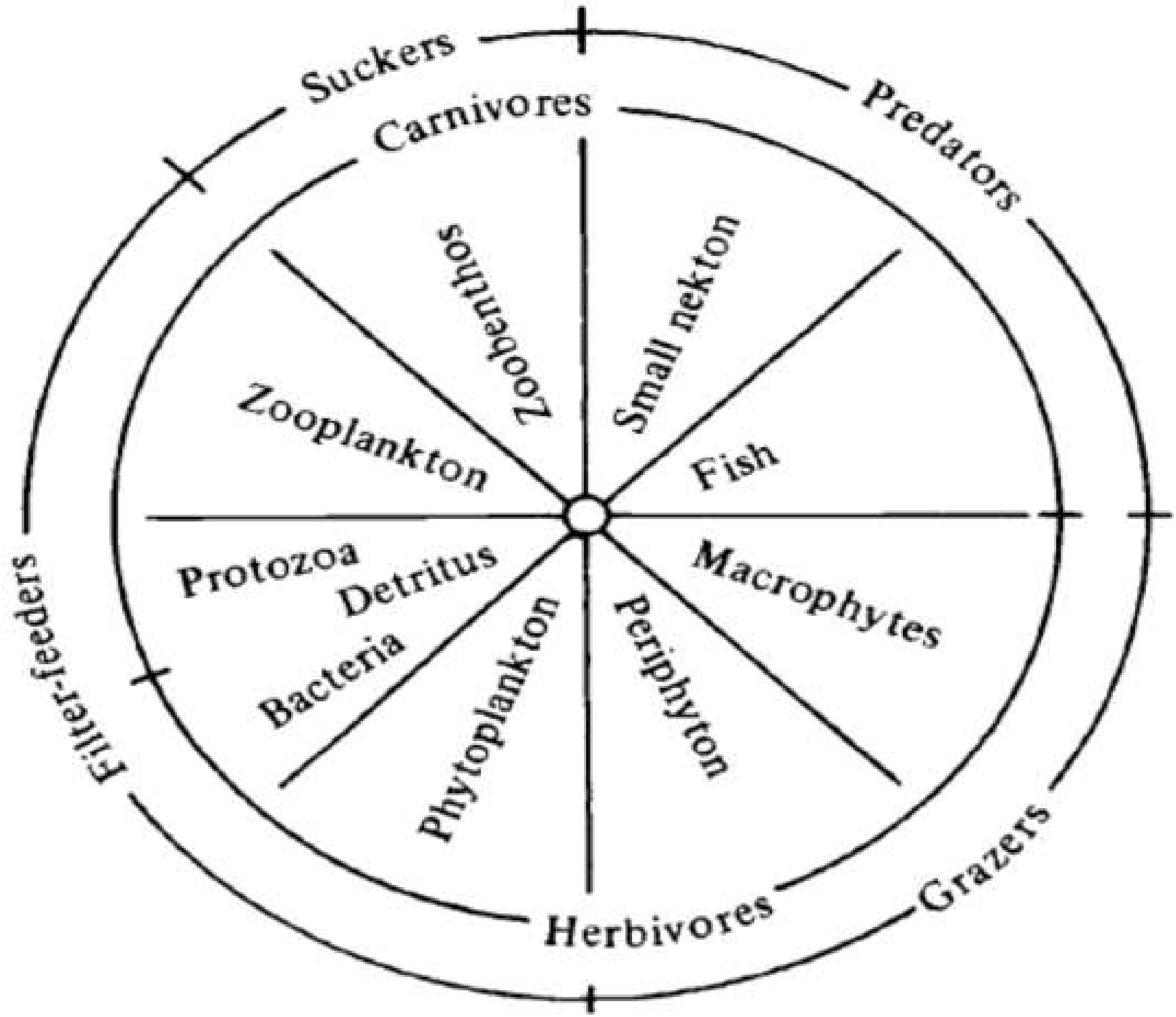


The amount of natural food available to fish in ponds (or any other water body) can be estimated in three ways: (a) estimating the natural food stock in the pond; (b) estimating the amount of food consumed by the fish; and (c) estimating the food intake indirectly through a bioenergetic balance analysis, taking into account fish weight, fish growth rate and energy expenditure for maintenance. The first method seems to be the most direct one. However, difficulties involved become immediately apparent. The first question to resolve is:

what is the natural food of a particular fish species?

All organisms, plants and animals, in the pond (or any other biotope) form the 'biocenose' of the pond and can serve as food for various fishes. These organisms interact with each other, mainly through predator-prey relationships, but also through others, such as competition for food, space, etc. These relationships have been described in many papers in various ways such as 'food chains', trophic levels creating a 'food pyramid' (in which the biomass of the lower trophic levels, especially primary producers, is much larger than that of the upper trophic levels, the consumers), as having intricate interrelationships of a 'food web', or otherwise.

Figure 32. The division of the biocenose to food organism groups according to their nature and size.



The biomass of each of the groups mentioned above can be determined and the 'biocenose profile' of the particular aquatic biotope thus obtained. However, from the nutritional point of view of the fish it is the production rate of these groups which counts, rather than the biomass at any given moment. When the production rates of each group of the biocenose is determined, the 'biocenose production profile' can be obtained. This is a long and tedious work and only very few studies gave the full biocenose profile, let alone biocenose production profile.

The most noticeable differences are between the larval stage, fry, and larger fish. Most fish feed in their young (late larval and fry stages) on zooplankton, even when the larger fish becomes herbivorous.Grass carp *(Ctenopharyngodon idella),* for instance, change from almost exclusively carnivorous to herbivorous feeding at a length of 25-30 mm. The same size was also found to mark the change in diet in gilthead bream, *Sparus aurata,* sea bass, *Dicentrarchus labrax* and the mullets *Liza ramada, L. aurata* and *L. saliens.* Also the diet of Indian carp *(Labeo rohita)* changes from zooplankton in the fry stage to phytoplankton in the adult stage. At a later stage, however, the trophic basis becomes more defined.

Food fish growth and fish yield relationships

Yield per unit area is a product of the individual growth rate and the number of fish per unit area (density). Since the individual growth rate is physiologically limited, the only way to increase yield per unit area is through increasing the density. As long as the amount of natural food exceeds requirements for maintenance and maximum growth, an increase in fish density (and thus also in standing crop) should not affect the individual growth rate of the fish. However, with the increase in standing crop the food requirement of the population also increases, until at a certain density/ standing crop food resources will be overloaded and will not suffice for both maintenance and growth.

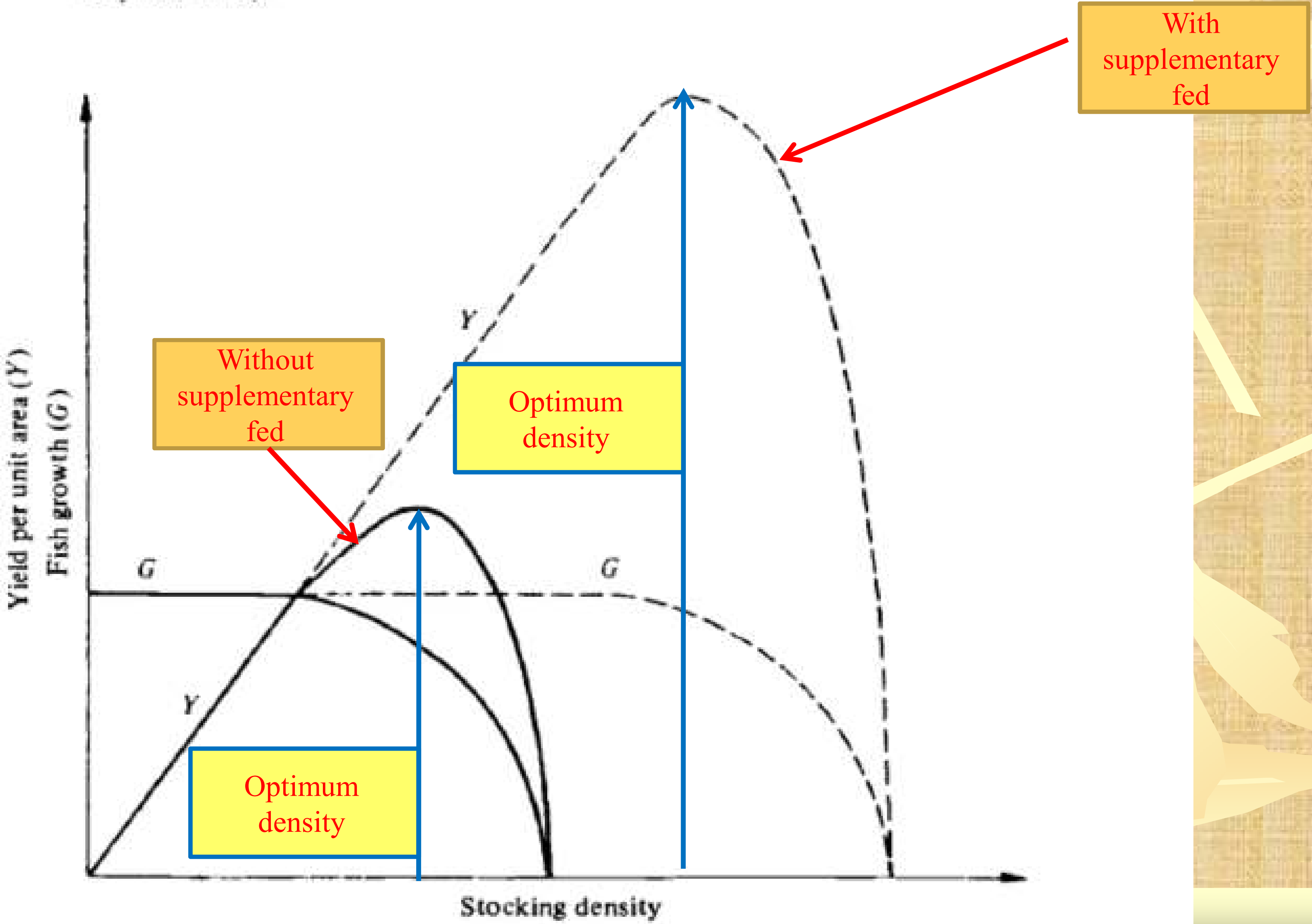
Food fish growth and fish yield relationships

Since maintenance is vital, less food will be diverted for growth, and individual growth rate will decrease. Hepher (1978) defined this standing crop as 'critical standing crop' ***(CSC).*** **When standing crop reaches a level at which natural food is sufficient only for maintenance and no food is left for growth, growth ceases entirely. This is the 'carrying capacity' of the pond for the particular species. The rate of decrease in individual growth rate as the standing crop increases over the** ***CSC*** **is at first smaller than the increase in fish density.**

Food fish growth and fish yield relationships

Yield therefore continues to increase, although not in proportion to the increase in density. At a certain standing crop, food demand for maintenance becomes so high that the decrease in individual fish growth rate becomes faster than the increase in density, and yield falls to reach zero at carrying capacity. If at standing crops above *CSC* the fish are fed supplementary feed of adequate nutritional quality, maximum growth rate will be maintained up to a point where some limiting factor in the feed will inhibit growth. Yield per unit area will thus continue to increase linearly with increasing density until the new *CSC* is reached. The larger the individual weight of the stocked fish, the higher the absolute food requirement for maintenance and growth.

Figure 31. Schematic presentation of the relationships between the stocking density, the short interval growth rate and the short interval yield per unit area, with (broken line) and without (solid line) supplementary feeding (from Hepher, 1978).



Food fish growth and fish yield relationships

Therefore, while the instantaneous growth rate of large fish below the *CSC* is higher than that of small fish, a given amount of food will suffice for a smaller number of fish and with increasing body weight *CSC* and carrying capacity will be reached at lower densities. The relationships between *CSC,* carrying capacity and body weight are, however, quite obscure. One may expect that since the *relative* requirement of food for maintenance and growth decreases with increasing body weight, the available food will be sufficient for a larger standing crop (kg/ha) of large fish than of small fish.

Food fish growth and fish yield relationships

However, farmers' experience does not support this. It has been noticed in practical fish farming that growth of fish ceases at a carrying capacity characteristic to the pond and method of its management irrespective of the average weight of the fish. Thus, for instance, if the carrying capacity of a pond is 150 kg/ha, at a density of 1500/ha fish will cease growing when they reach an average weight of 100 g, but 15 000 fish/ha will cease growing when they reach 10 g. In many cases it has even been observed that the smaller fish reach a higher carrying capacity than do large fish. This discrepancy may perhaps be explained by the higher efficiency of grazing and predation as the density increases . Using the above example, 15 000 fish each of 10 g have a greater capacity to graze or seek and catch prey than 1500 fish/ha of 100 g.

Food fish growth and fish yield relationships

From the above discussion it is clear that the main factor determining the *CSC* and the carrying capacity is the productivity of the pond, the treatment it gets (fertilization and manuring) and supplementary feeding. It should be noted that supplementary feeding has no effect below the *CSC* since fish receive all their nutritional needs from the natural food. The amount of food to be supplemented above the *CSC* depends on the available natural food on the one hand and the standing crop of fish on the other. The higher the standing crop, the less natural food can satisfy the fish nutritional requirement, and more supplementary food is needed to bridge the gap. It is obvious that for calculating the amount of supplementary feed required one must first estimate the amount of available natural food.

Pond Management

Critical standing crop and carrying capacity are important concepts in aquaculture (Hepher 1978). For any given pond management strategy, fish will grow at a maximum rate until food or some other environmental factor becomes limiting, causing growth to deviate from its maximum rate. The level at which growth deviates from the maximum is referred to as the critical standing crop. Fish continue to grow once the critical standing crop is exceeded, albeit at a decreasing rate, until growth ceases and conditions in the ponds are sufficient only to maintain the fish population without growth. This point is referred to as the carrying capacity. If the factor that limits growth is removed, fish once again can grow at a maximum rate until another factor limits growth, causing the growth rate to decline until the population reaches a new carrying capacity (see Figure 7.1). Below the critical standing crop, absolute fish growth rate ($g \cdot day^{-1}$) increases linearly as fish individual weight increases. Above the critical standing crop, yield ($kg \cdot ha^{-1} \cdot day^{-1}$) continues to increase as long as growth rate decreases more slowly than the increase in fish weight. Thus, maximum yield ($kg \cdot ha^{-1} \cdot day^{-1}$) occurs between the critical standing crop and the carrying capacity. Total production ($kg \cdot ha^{-1}$) continues to increase until the carrying capacity is attained; however, the yield equals zero at the carrying capacity. Harvesting ponds near the time of reaching maximum yield generally

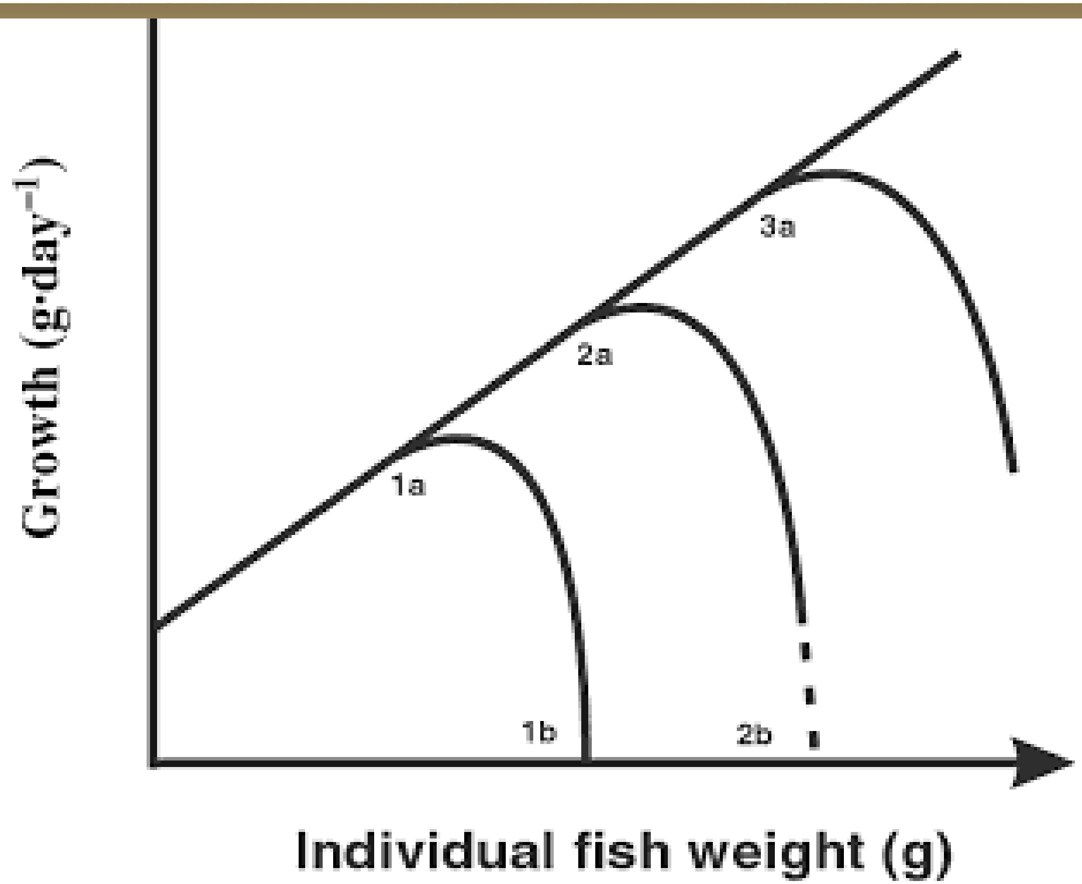
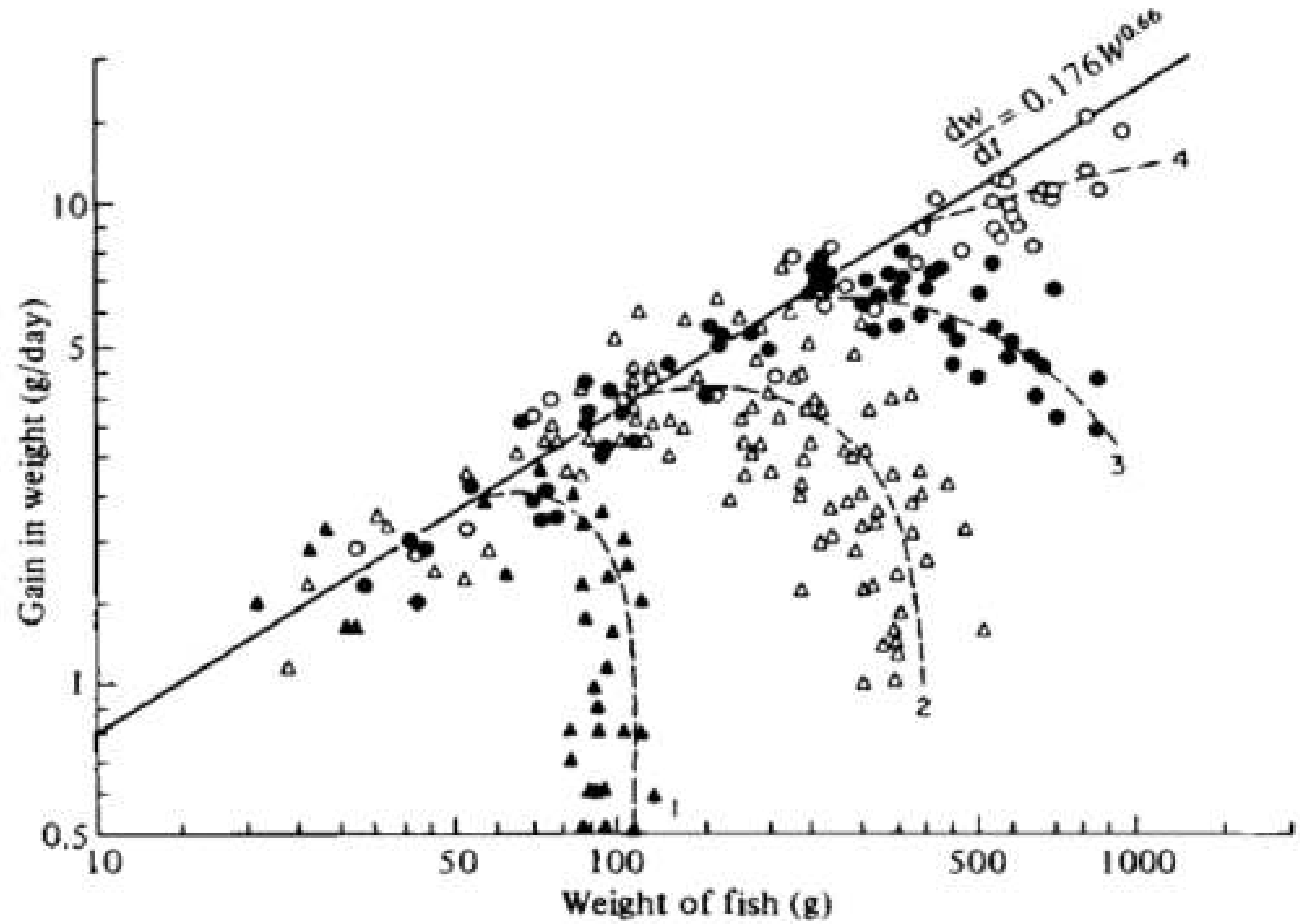


FIGURE 7.1. Generalized relationship between fish growth and individual fish weight. Fish will grow at a maximum rate under a given management system until some factor limits growth (points 1a, 2a, 3a, referred to as the critical standing crop). Growth rate will decline until growth ceases once the fish population reaches the carrying capacity (points 1b, 2b). If the constraint to growth is removed, fish resume maximum growth until the next factor limits growth, and so on. *Source:* After Hepher 1978.

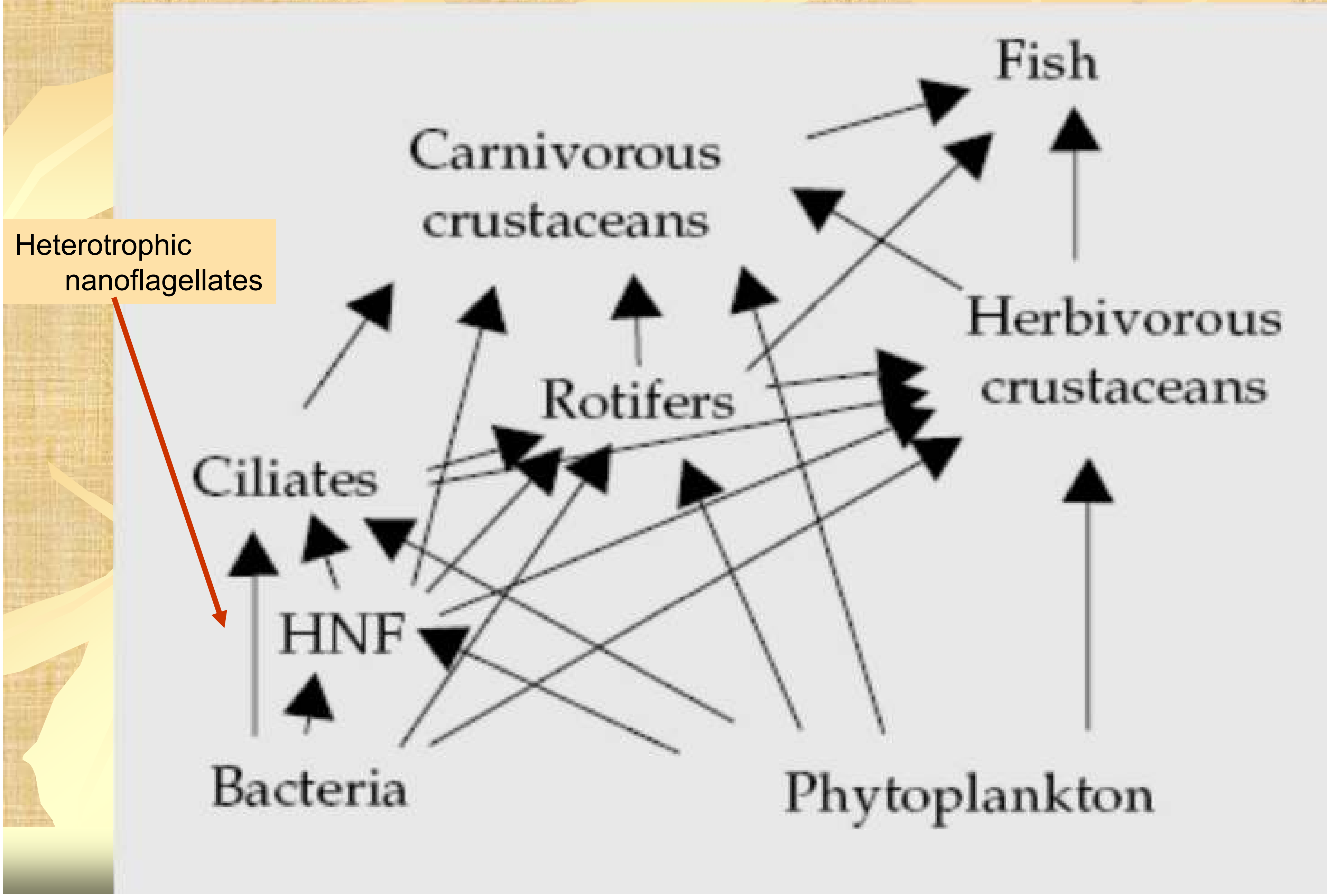
Food fish growth and fish yield relationships

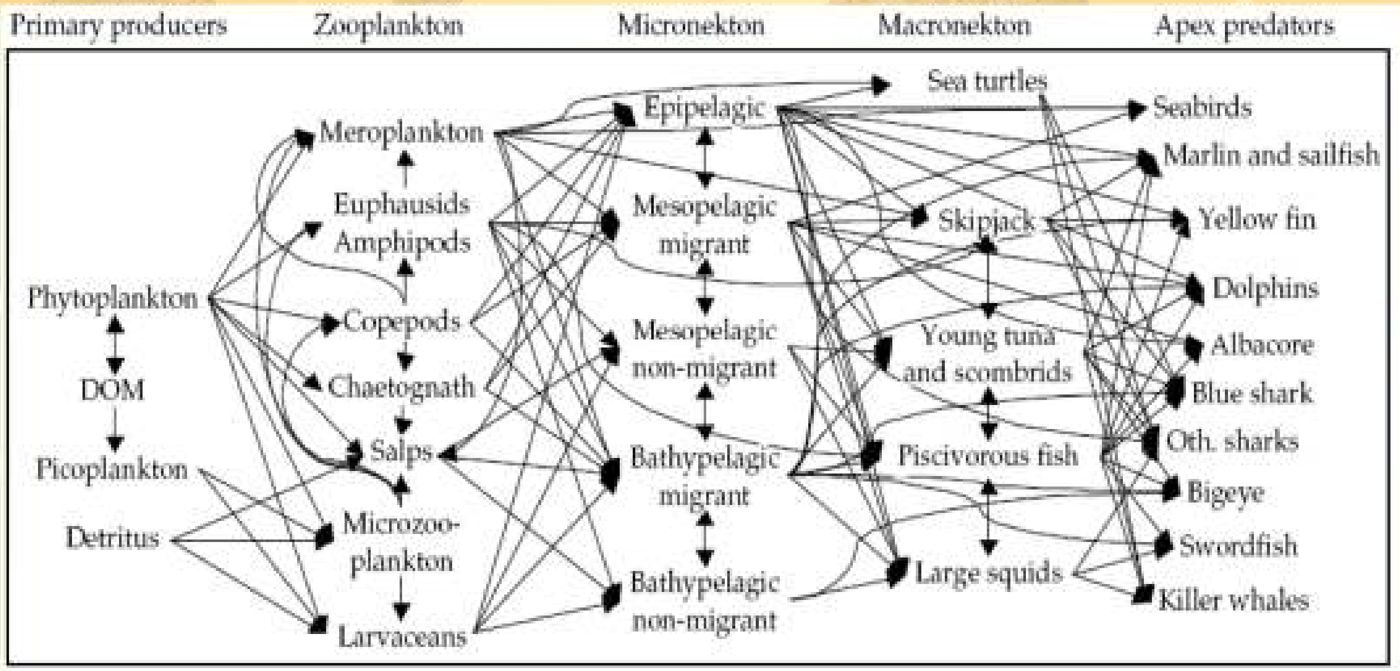
Treatment	CSC (kg/ha)	Carrying capacity (kg/ha)
No fertilization, no feeding	65	130
Fertilization but no feeding	140	480
Fertilized and fed sorghum	550	2500 (estimated)
Fertilized and fed protein-rich pellets	2400	—

Figure 23. The relationship between growth rate (g/day) and the average weight (g) of common carp, as determined by two week interval sample weighings for four treatments: (1) no fertilization and no feeding (black triangles); (2) fertilization but no feeding (empty triangles) (3) feeding on sorghum (black circles); (4) feeding on protein-rich diet (empty circles). Each point is an average value determined from four replicated ponds.

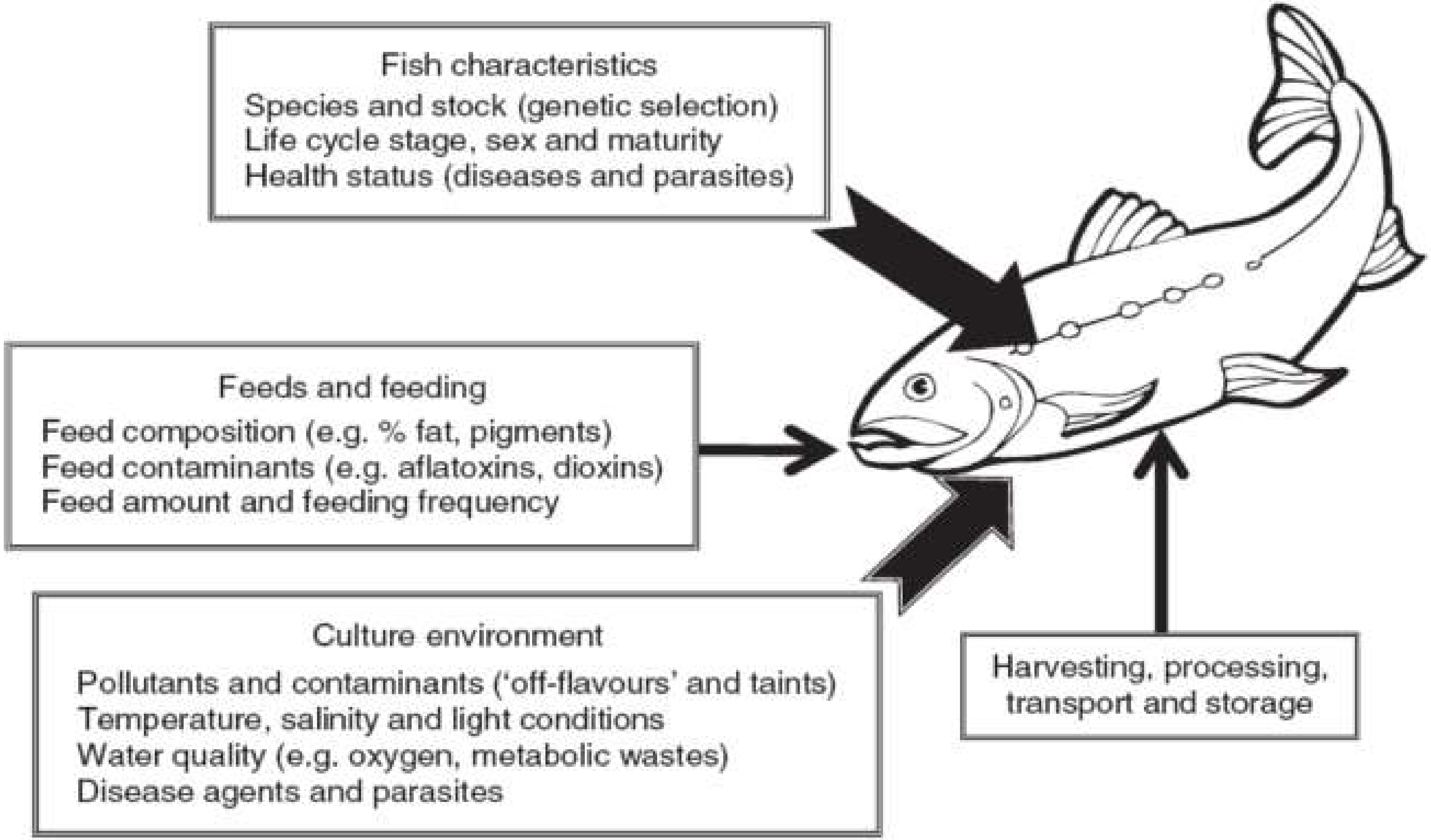


Pelagic food web into eight trophic





Food web for studied system. Arrows point from the prey to the predator DOM: Dissolved Organic Matter



The major factors influencing flesh composition of farmed fish. The factors that play a role in determining the composition and 'quality' of the fish that reach the market are :

1- Intrinsic (relating to the fish themselves) .

2- Extrinsic factors (relating to feeds and feeding and the culture environment)