Unit 3. Fish Ecology
Outcome 2: Principle Commercial species in the Mediterranean.
Part 2: Biological, ecological and dynamic characteristics

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Population Dynamics is a field of scientific research developed earlier this last century in the North Atlantic, to understand the behaviour of exploited marine populations, especially this discipline has become extremely important due its economic and social consequences, when used in support of **assessment and management of fisheries**. A very important element of Populations Dynamic Analysis and in consequence for Stock Assessment, is the attempt to quantify values for the **biological parameters** considered by the mathematical models and the predictions of these models are very sensitive to the estimates of biological parameters used.

Although the hydrographic and bioclimatic conditions of an area determine the conditions under which a population can exist, normally they are not considered by the models of population dynamics currently in use. But there are two main factors which limit the biomass of the population: **the primary production and the available habitat** or space, that are not usually taken in account either. However, it is imperative to keep them in mind.

SUMMARY

1. **Life History Strategies**
2. **The biological/dynamic parameters and the lifespan of species**
3. **The Growth Funtion**
4. **Spawning**
5. **The Mediterranean resources and their characterisation. The target and by-catch species.**
6. **By-catch species.**

1. Life History Strategies

The usefull, if rather over-simplified concept of r-K continuum of life history strategies, first coined by MacArthur and Wilson (1967), has proved valuable in attending to integrate life history information in relation to the role of a species in the marine ecosystem, even if it is difficult to quantify in practical terms. Stated simply, it is postulated that two major evolutionary strategies can be recognized, r and K selection, each of which is particularly adapted to characteristic patterns of change in the biotic or abiotic environment.

There are a lot of usefull functions which help to explain the basic concepts of this continuum r-K. These funtions describe asimptotic fenomena like the increase of a population and the use of more space or the consumption of limitated resources like food, approaching an assimptotic value of maximum biomass. We can observe the increase in biomass of a population as proportional to the reproduction rate r, under the assumptions of the logistic model:

$$dB/dt = rB$$

If the limitant factors are taken in account, the increasing rate of biomass growth can be considered a measure of the speed with which the biomass of a stock of a species reaches the maximal assimptotic value established by these factors. If K express this limit and r is the maximum rate of increase we could use the logistic equation suggested by Verhulst-Pearl, commonly used in demografic studies, where K represent the limitations mentioned (Fig.1):

$$dB/dt = rB - (r/K) B^2$$ [1]

[1] r is the maximum rate of increase that a population of initial size (B) exhibits when released from exogenous limitations (i.e. not food limited, little predation, etc), and K the carrying capacity of the system, equivalent to the virgin biomass or the carrying capacity of the environment in the usual fisheries formulation.

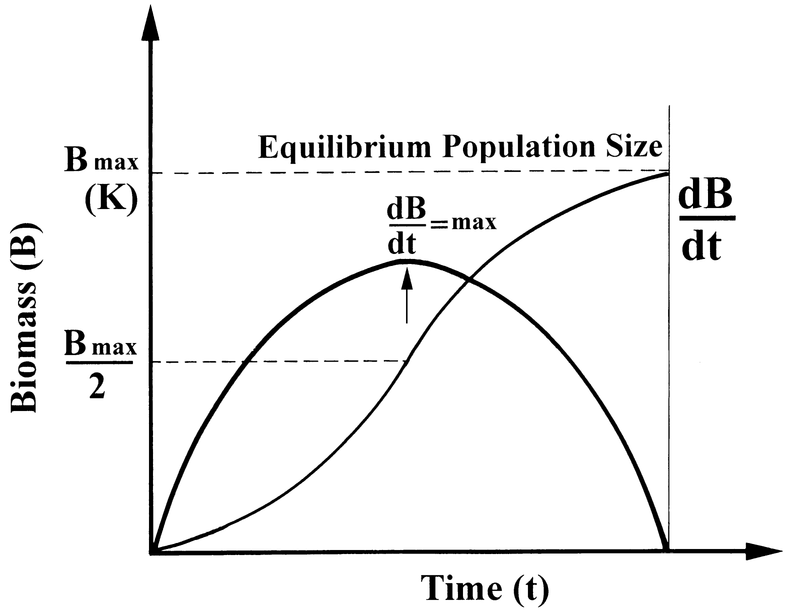


Figure 1. Rate of change of population size and growth of population size with time as described by the logistic model

The r-strategists are species adapted to living in environments where there is a high density-independent mortality rate. Such areas include high latitude seas where (for annual species at least), seasonal periods of high food abundance are followed by periods of relative scarcity. These species tend to allocate a greater proportion of their resources to reproduction, having in consequence a high gonadosomatic ratio and birth rate, a short life span, as well as being in general relatively unspecialized, especially for example in feeding habits. Population size is generally prone to high fluctuations in numbers (e.g., Engraulid and Clupeid species).

By contrast, K strategists are adapted to living in environment, relatively stable, where intra- and interspecific competition is high. There is consequently a high degree of selection by means of density dependent factors, and these species have evolved to allocate a greater proportion of their resources to non-reproductive activities promoting individual survival. They are consequently relatively specialised in their trophic activities and other behaviours, and in general are longer-lived, less fecund, and less prone to major short-term changes in population size (e.g. sharks and whales).

Pianka (1972) notes that although some species are particularly adapted to rapidly occupying vacant spaces on the ecosystem (r-strategists), others are better adapted to slowly increasing their share of the resources of the system under conditions of high competition (K-strategists). In his general review of the field, Pianka (1970) notes that in terrestrial systems there is a very clear distinction between the two strategies, and that in fact, for terrestrial animals this results in a clearly bimodal distribution of sizes, between small (predominantly annual) arthropod-dominated species, and larger, often perennial vertebrates. However, Pianka notes that fish show the full range of the r-K continuum. A summary of the main characteristics of r and K species is given in Table 1.

Characteristics	r-selected	K-selected
Climate	Usually variable and/or unpredictable	Fairly constant and/or predictable (or species shows migratory behaviour)
Risk of natural death	Often high or catastrophic; largely independent of population size	Death rate is more scheduled and dependent on population size
Population size	Variable in time, non-equilibrium conditions prevail; occupies ecological vacuums but rarely reaches the carrying capacity of the environment	Fairly constant in time, at or near carrying capacity of environment
Competition between species and within species	Generally lax	Usually keen
Length of life	Short	Longer
Natural selection in favour of:	(1) Rapid development	(1) Slow development
	(2) High rate of population increase	(2) Low rate of population increase
	(3) High rate of egg production	(3) Low rate of egg production
	(4) Small body size	(4) Large body size
	(5) Single reproduction	Multiple reproduction
	(6) Less emphasis on behavioural and morphological characteristics to increase individual survival habits	(6) Behaviour and morphology assures good individual survival, e.g., territorial behaviour, spines, special dentition and special feeding habits
All above lead to:	Productivity	Efficiency

Table 1. Some characteristics of r- and K-selected species.

2. The biological/dynamic parameters and the lifespan of species

From a similar point of view the lifespan has been frequently used by fishery biologists to classify species. Attending to this characteristic the species can be grouped as long-lived and short-lived species.

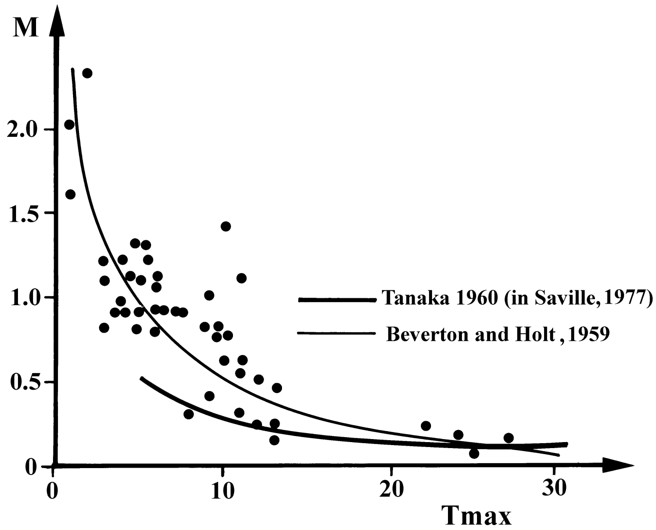
Short-lived species of fishes are characterised by the rare presence in the population of individuals of more than 4 years. M is usually high, in the order of M=1, with a survival rate of 35-40% in unexploited conditions. The growth rate is high and they reach the sexual maturity in the next year. These species are very influenced by environmental changes. Normally its populations are very variable due to the fact that they are dependant almost exclusively on the most recent recruitments. For that, when these populations are exploited, it is necessary to look for maintaining a minimum acceptable level of spawning stock in order to avoid collapses. On the other hand provided this level is maintained, high levels of fishing mortality can be applied.

Long-lived species of fishes remain in the population 10 or more years. Normally M vary between 0.1 and 0.5 (i.e. a survival rate between 60% and 90% when unexploited). The growth rate is low, and are not fully reproductive until the 3rd year or more. These populations are more stable than the short-lived ones due the fact the large number of age groups reduce the impact of fluctuations of recruitment. In these populations the Yield per Recruit curves are more often used to assess it.

	Livespan	Natural Mortality (M)	Growth $L_t = L_\infty (1- e^{-K (t-to)})$	Sexual Maturity	Environment dependency
Small pelagics	4 years (exploited fase)	High (≈1) Surv.of 35-40%	Fast K high (0.5) L_∞ low (-50cm)	1st year	Strong Fluctuant
Demersals	10 years or more	Baja ≈ 0.1-0.5 Superv.No explot. 60-90%	Slow K low (0.1) L_∞ high (1m)	More than 3 years	Litle Stable

TABLE 2

Somehow, the named "long-lived" species of fishes can be identified with those difined as K-strategist ones and the named "short-lived" species, more oportunistic, with the r-strategist ones. Once we have to insist with the problems of oversimplification, but sometimes could be usefull to be aware of this dictinction.



A relationship between longevity/lifespan Tmax (in years) and natural mortality (M) can be stablished, i.e., the species with a high mortality rate are short lived (see Figure 4).

3. The Growth Funtion

The growth in length and weight, the natural mortality rate, and the relation stock-recruitment or an index of recruitment have to be estimated. A simplification of one of the most refereed models, the Von Bertalanfy Growth Function can be used to show how these parameters are integrated (Figure 5):

$$W_t = a\,L_\infty^3\,(1- e^{-k(t-to)})^2$$

[2] Von Bertalanfy Growth Function (VBGF) where L_∞ k and t_o are

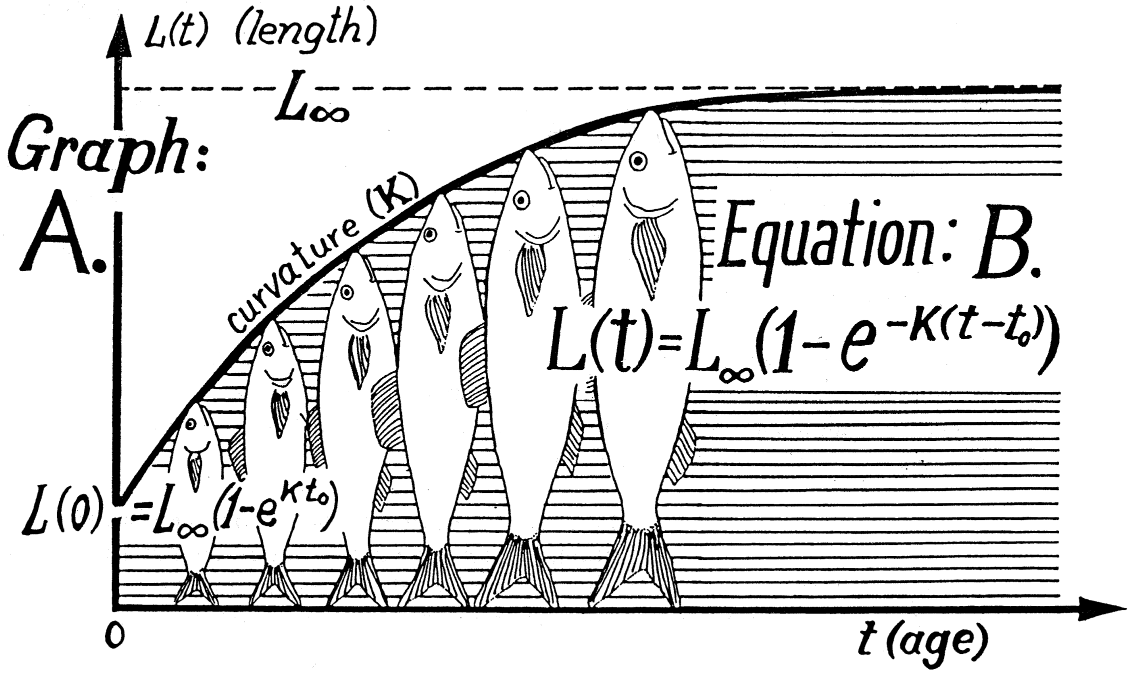
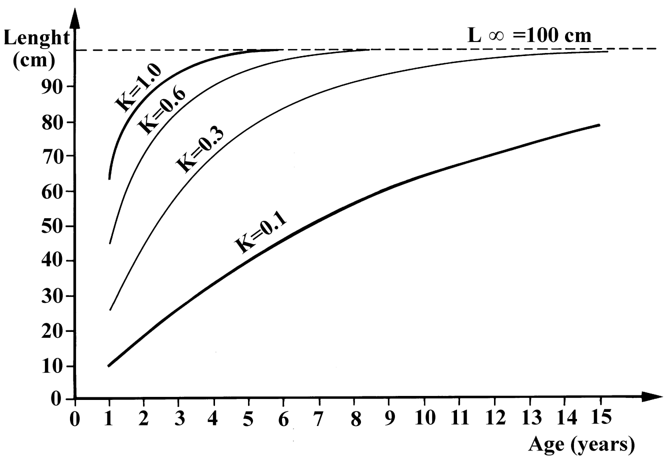


Fig. 3.1.0.1 The von Bertalanffy growth equation

Figure 6 shows as how VBGF changes with different values of K (like a speed of growth) and maintaining L∞ (= 100 cm) and to (= 0) costants. When K is 0.1 individuals of 1 year reach 9.5% of L∞; when is 0.3 are 26%, a 45% when K is 0.6 and 63% when is 1.



Also a constant M/K relationship is observed in groups of species evolution related; i.e. the speed to the maximum size is bigger when high natural mortality rate exits. Finally a relationship has been shown between Tmax and L∞ also for a group of species (Figure 4b)

4. Spawning

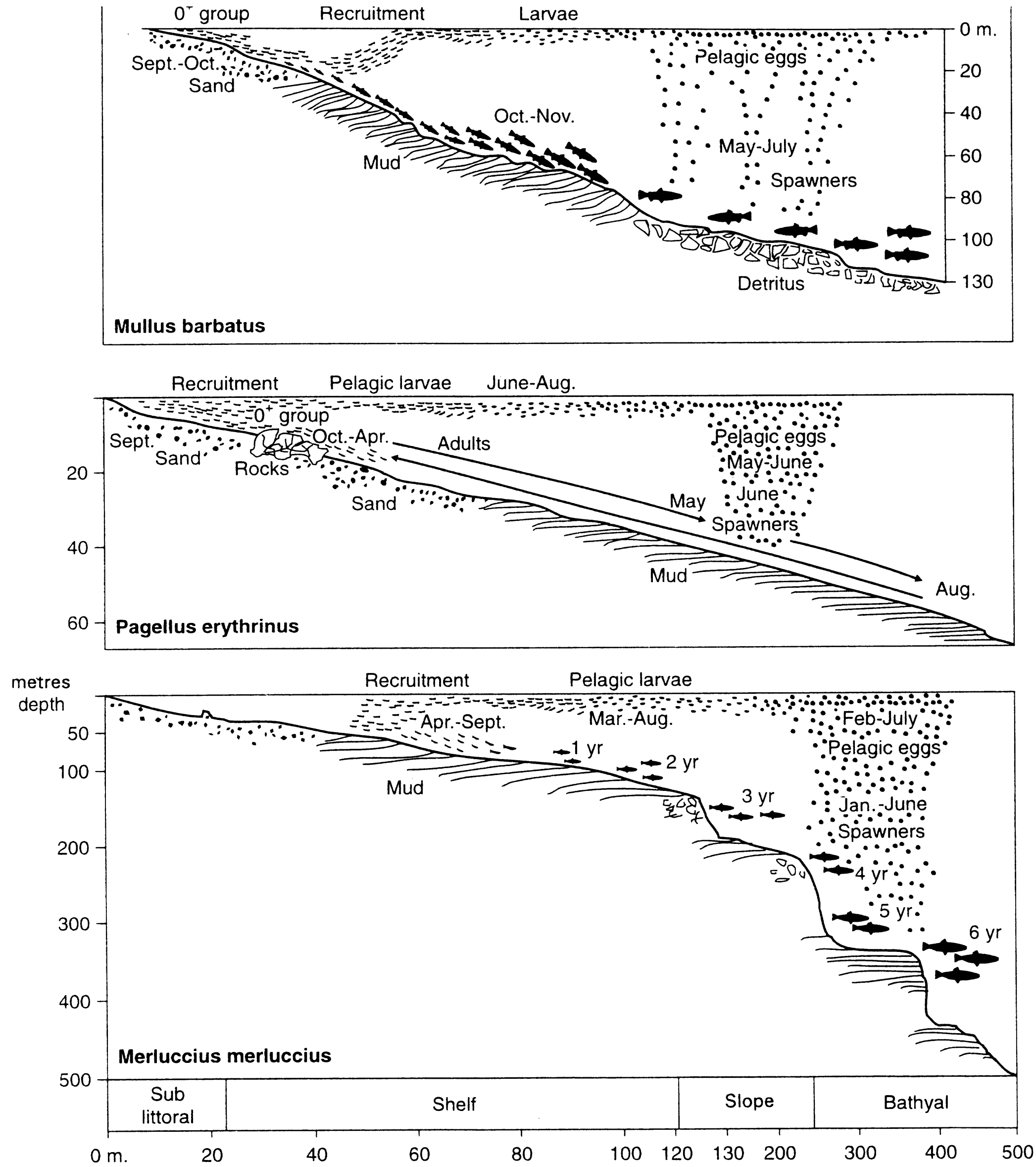


Fig. 7. Vertical displacements during life histories of 3 common demersal fish species (after Doumerge)

5. The Mediterranean resources and its characterisation.

6. TheTarget and by-catch species.

Concerning catch composition, and despite the inherent complexity of multi-species landings in Mediterranean ports, there is an identifiable series of target species which, in biomass or in economic terms, constitute the basis of production. These are sardine (Sardina pilchardus) anchovy (Engraulis encrasicholus) among the small pelagics; hake (Merluccius merluccius), red mullets (Mullus spp.), blue whiting (Micromesistius poutasou), anglerfishes (Lophius spp.), Pagellus spp., Octopus spp., squid (Loligo spp.), and red shrimp (Aristeus antennatus) among the demersals; and, prominent among the large pelagics, bluefin tuna (Thunnus thynnus) and swordfish (Xiphias gladius) with other species of local interest in specific sites (FAO 1993). These species represent 70-80 percent of all landings, at least eight of them over 2 percent of the total catch, and two over 15 percent.

Nevertheless in the Mediterranean trawl fisheries sometimes it is not easy to separate target (many times this does not represent more than 20% of landings) to by-catch species because they can change depending of the period of the year, the place and other circumstances. By-catches may include small sharks and rays, a group of species that are commercialised together and that can represent, in some cases, up to 40% of total trawl landings. Other species could be cited as by-catches; for example, those caught in small quantities, but important due their economic value; some small pelagic species; several types of shrimps and other crustaceans and cephalopods.

Sardine and anchovy are the main target species and mackerels, horse mackerel, bogue, some sparidae and gilt sardine can be cited as by-catch. The main small scale gears are trammel nets, gillnets, bottom long lines to fish hake, spiny lobster, red mullet, cephalopods, Poliprion, scorpaenidae, triglidae, Phicis, Serranidae, Trachinus, Trachurus, Scomber, Sarda, Lophius, Boops, Trisopterus and Sparidae, traps to fish Plesionika, spiny lobsters and octopus and dredges to catch bivalves as Donax trunculus, Chameachea gallina, Acantocardia tuberculata, Pecten jacobeus, Callista chione, Venerupis rhomboides or Mactra coralina.

Finally the fleets using floating drifting longline to catch swordfish and tuna long lines and tuna purse seine must be mentioned as surface gears. The main by-catch species of these gears are sharks, marine turtles and also dolphin fish and birds.