

UNIVERSIDADE DO ALGARVE

Unidade de Ciências e Tecnologias dos Recursos Aquáticos

**Biometry and body chemical composition of some Japanese and European fish
species in culture**

Dissertação apresentada para obtenção do grau de
mestre em Mestrado em Aquacultura

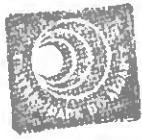
Elsa Correia dos Santos

Faro
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ABSTRACT

The present study considers the relationship between total body weight and other body parameters (length and condition factor), several physiological indices (hepatosomatic index, gonadosomatic index, viscerosomatic index, gut index and visceral fat) and crude composition (moisture, fat, protein and ash) in yellowtail (*Seriola quinqueradiata*), amberjack (*Seriola purpurascens*), red seabream (*Pagrus major*), seabream (*Sparus aurata*) and seabass (*Dicentrarchus labrax*). The results showed that from the regression equations determined, the weight or percentage of an organ or tissues can be estimated with a high degree of accuracy from the simple knowledge of body weight.

Relating the condition factor with body weight and the parameters with interest to the aquaculturist (percentage of dressed weight, viscerosomatic index, proportion of visceral fat and of total body fat) in a 3D scatter plot, it was possible to observe how changes in condition, induced by the rearing conditions, affect those parameters, and, consequently, the production level. The results showed that muscle is the principal site of fat stores in yellowtail, while for seabass, viscera appears to be the principal site, due to the great amount of fat deposited in the abdominal cavity. No conclusions could be made for the rest of the species due to the lack of significant results.

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1 INTRODUCTION

Growth can be measured in terms of number, linear dimension, weight, volume, energy content or the amount of a specific component such as protein (Busacker *et al.*, 1990). Growth measured in terms of biomass is important to the aquaculturist. Nevertheless, the knowledge of the particular characteristics of growth in fishes could benefit fish culture, because an analysis of relative growth of tissues can provide an insight into those fish growth processes concerned with the proportional partitioning of protein, lipids and energy within the body. Fish could be harvested in terms of maximisation of growth of the more useful components, such as protein, as has long been the case for farm animals. But this will become possible only when there is more complete knowledge than at present, of proportional shifts in relative sizes of tissues and of their protein, lipid and energy contents as fish body increases in size (Weatherley and Gill, 1989).

The growth of organs and tissues occurs according to certain patterns characteristic of each species. In the natural environmental there are factors that can change or modify growth. In aquaculture growth is also influenced by the aquaculturist.

From the point of view of the aquaculture, the principal objective is the production in terms of biomass, in the shortest possible period of time. But there are other aspects which should be given some attention, particularly those related to quality. Most research for improving aquaculture production has been devoted to the increase in growth performances in quantitative terms, but very little towards flesh quality (Corraze *et al.*, 1993). In Norway, quality has been a question of body size (larger fish demands higher price per kg), meat colour (salmon red colour), and external appearance (no defects, etc.). However, an optimum body composition also exists, although this optimum may vary from one market to another as well as within a market, depending on how the final product is prepared (Gjerde, 1989).

Associated with flesh quality is the fat content of the fish and the sites where fat is stored, which may differ from species to species. The aquaculturist has to consider several aspects

simultaneously, in order to plan properly his production to attain his aim. Thus, it will be important for him to know, for a particular species, the maximum levels of production in terms of muscle, in a way to obtain the optimum amount of fat.

Standard values for the different aquaculture species should be determined, as has been done in Japan, where values of crude composition for several species are included in standard tables of food composition. The fish industry and consumers will in future need increasingly more information and guarantees of the chemical composition of fish (Fauconneau *et al.*, 1995).

Developing growth models, can predict growth accurately only if feeding, one of the factors included in the model, is adjusted to the species. Successful cultivation of marine fish implies a good knowledge of feeding strategy as a function of animal size and environmental conditions. Thus, the knowledge of the relative growth of tissues is important from a nutritional point of view.

Body composition in mammalian species has been studied since the early years of this century, and these studies have led to the development of allometric equations for indirect computation of body composition. Typically, body composition of fish is assessed by proximate chemical analysis, which is time-consuming and requires the death of the fish. The estimation of total body composition through the application of allometric equations based on easily measured parameters, such as fork length and live weight, would allow fish to be released unharmed after weight-length measurements.

The physiological indices (condition factor, hepatosomatic index, etc.), used to evaluate the condition or well-being of fish, are an easy and rapid means of estimating growth and body composition (correlated with, e.g., protein, lipids, etc.), and as indicators of environmental conditions. Although affected by several environmental factors, they are widely used.

In addition to the economic aspect, the cost of chemical analysis and death of fish, the knowledge of the relationships between the several body traits and body composition would

have application to aquaculture. The aquaculturist could monitor indirectly the levels of fat and protein, at various stages of growth.

The production of yellowtail (*Seriola quinqueradiata*) and red seabream (*Pagrus major*) in Japan, 90% of the total fish culture production (Honma, 1993), shows the importance of these species in Japanese aquaculture. Amberjack (*Seriola purpurascens*) is a new species that now is being considered for aquaculture in Japan. Seabream (*Sparus aurata*) and seabass (*Dicentrarchus labrax*) are the main European species produced by aquaculture in the Mediterranean. Therefore, the proper knowledge of the biology and growth of these species is important in order to develop this industry further, for instance, with respect to better feeds and feed conversion.

The general objective of the present study is an elucidation of the relationships among several biometric and compositional parameters in fish species used in Japanese and European aquaculture. The species included are yellowtail (*Seriola quinqueradiata*), red seabream (*Pagrus major*), amberjack (*Seriola purpurascens*), seabream (*Sparus aurata*) and seabass (*Dicentrarchus labrax*).

1.1 FISH GROWTH

1.1.1. LENGTH-WEIGHT RELATIONSHIP

The term growth can have different meanings, depending on which variable is being studied. As Weatherley and Gill (1989) have stated, “the variable undergoing change may be length, or other physical dimension, including (...) weight (...) either of an organism’s whole body or of its various tissues; or it may relate to the content of protein, lipid or other chemical constituent of the body (...)”.

The characteristics of growth in fish are different from those of higher vertebrates. In fish growth rates show great variation (within and between populations) because fish respond

sensitively to environmental factors, such as differences in food supply, population density, temperature, etc. (Weatherley and Gill, 1989).

The quantification of changes in size can be made measuring several variables, but weight and length are the most commonly used as direct assessment of the whole body growth of fish. These two variables are relatively easy to measure and whole animals can be measured without killing them.

The length of a fish is often more rapidly and accurately measured than the weight. Weight may be a transient indicator of growth, because it can be affected by several factors. For instance, stomach content and gonad weight (Ricker, 1979; Busacker *et al.*, 1990) are two possible sources of variability in weight. However, this possible variation can be surmounted by eliminating the weight of gonads and/or stomach content from the measurements, if the purpose of the study allows. In a study in perch, *Perca fluviatilis*, Le Cren (1951) reported that the weight of food in the stomach was not responsible for the individual variation in weight, but the gonad weight was responsible for the seasonal differences between immature and mature fish.

Fish length can be measured in many different ways, although total length, fork length and standard length are the most commonly used. Ricker (1979) described the differences between the methods and commented that fork length is the one widely used by fisheries biologists for both marine and freshwater species.

Since the growth implies change in both weight and length, the mathematical relationship between these variables permits the calculation of one from the other. The weight-length relationship is generally expressed by the equation, $W=aL^b$ where W =weight (g), L =length (cm), a is a constant and b an exponent the value of which lies between 2.5 and 4.0 (Le Cren, 1951).

If a fish maintains a constant shape as it grows, the value of the exponent b is 3, which means that weight increases as the cube of length, but in many instances the cube law is not

obeyed and \underline{b} does not equal 3 (Le Cren, 1951; Ricker, 1979; Weatherley and Gill, 1989). Busacker *et al* (1990) reported that the values of \underline{b} generally fall between 2.5 and 3.5.

There are a great many published reports on the length-weight relationship of individual fish. Table 1.1. shows this relationship in different wild or cultured species with commercial interest. From the data in the table, it is possible to observe that almost all species have allometric growth, which means that \underline{b} does not equal 3.

Groves (1970) reported that “ for any particular species, variations in the equations relating weight to length, having the formula $W=aL^b$ occurred primarily in the factor \underline{a} and resulted from differences in the “condition” of groups of fish sampled at different times”. As pointed out by Safran (1992), the variability in \underline{b} found in juveniles of yellowtail, *Seriola quinqueradiata*, reflects a difference in morphology among individuals and not allometric growth. Also, Goulart and Veroni (1992), refereed that the small variations in \underline{b} , observed in *Hypostomus commersonii*, are conditioned by different environmental conditions and biogenetic aspects inherent to each species. The strong correlation between \underline{a} and \underline{b} , reported by Safran (1992) could be explained by colinearity. Only \underline{b} seems to be important and to be a key parameter in the weight-length relationship.

The use of the log transformed equation, $\log W = \log a + b \log L$, assumes constancy of $\log a$ and b . Because this equation represents a fundamental concept in biology, Xiao and Ramm (1994), studied the implications that a variability in $\log a$ and b may have in the allometric equation. Biological phenomena, such as genetic, phenotypic and/or behavioural variability among individual animals, are causes of variability in the allometric parameters. These authors could find no gain of precision in accuracy of estimates of allometric parameters, reporting that individual variability in those parameters probably has a negligible effect on allometric predictions in length and weight relationship.

Table 1.1. W-L relationship of different species (wild and cultured).

SPECIES	ORIGIN	SIZE	$W = aL^b$	SOURCE
Grey mullet (<i>Liza malinoptera</i>)	wild	1.3-9.1 cm	$0.01944L^{3.0959}$	Ching, 1977
Perch (<i>Perca fluviatilis</i>)	wild (F) (M)	26.0 cm 22.5 cm	$0.01410L^{2.91923}$ $0.00609L^{3.17514}$	Craig, 1977
Roach (<i>Rutilus rutilus</i>)	wild (M) (F)	7.2-23.0 cm	$0.0356L^{3.40}$ $0.0215L^{3.61}$	Papageorgiou, 1979
Tilapia (<i>Tilapia zillii</i>)	cultured (M) (F)	3-12 cm	$0.01965L^{3.3619}$ $0.01967L^{3.3629}$	Dadzie & Wangila, 1980
Carp (<i>Barbus grypus</i>)	wild	12.6-97.5 cm	$5.89E^{-5}L^{2.6832}$	Al-Hakim <i>et al.</i> , 1981
Common carp (<i>Cyprinus carpio</i>)	wild (F) (M)	23.8-57.8 cm	$5.358E^{-5}L^{2.80}$ $2.063E^{-3}L^{2.98}$	Crivelli, 1981
Luderick (<i>Girella tricuspidata</i>)	wild	22.0-42.0 cm	$1.56E^{-5}L^{3.02}$	Pollock, 1981
Cod (<i>Gadus morhua</i>)	wild (mature) (immature)	15-80 cm	$0.01103L^{2.9510}$ $0.00555L^{3.1131}$	Eliassen & Vahl, 1982b
Pollan (<i>Coregamas autumnalis pollan</i>)	wild	3.5-30 cm	$0.00575L^{3.202}$	Wilson & Pitcher, 1983
Seabream (<i>Sparus aurata</i>)	wild cultured	5-26 cm 5-26 cm	$0.00687L^{3.2216}$ $0.004857L^{3.3616}$	Eisawy & Wassaf, 1984
Milkfish (<i>Channos chamos</i>)	wild cultured	9.2-34 cm 2.0-9.0 cm >10 cm	$2.464E^{-6}L^{3.2598}$ $5.0222E^{-6}L^{3.2388}$ $6.137E^{-6}L^{3.1831}$	Bagarinao & Thayaparan, 1986
Goatfish (<i>Mulloidides flavolineatus</i>)	wild	16-31.9 cm	$0.00860L^{3.0396}$	Al-Absy, 1986-87
Seabream (<i>Sparus aurata</i>)	wild / cultured	6-22 cm	$0.0130L^{3.1384}$	Ramos, 1987
Goatfish (<i>Parupeneus cinnabarinus</i>)	wild	12.7-36.4 cm	$0.007367L^{3.1748}$	Al-Absy & Ajiad, 1988
Seabream (<i>Sparus aurata</i>)	cultured intensive cultured semi int. cultured extensive wild - cult.inten. wild - cult.exten.	2-13.9 cm 5.1-15.9 cm 2.0-17.2 cm 2.9-15.5 cm 2.9-17.2 cm	$0.0101L^{3.351}$ $0.0126L^{3.223}$ $0.0107L^{3.260}$ $0.0084L^{3.349}$ $0.0072L^{3.363}$	Francescon <i>et al.</i> , 1988
Horse mackerel (<i>Trachurus trachurus</i>)	wild	8.9-42.3 cm	$5.24966E^{-6}L^{3.061}$	Lucio & Martin, 1989
Greenback mullet (<i>Liza subviridis</i>)	wild	14.5-31 cm	$1.1204E^{-5}L^{3.0073}$	Al-Daham & Wahab, 1991
Striped bass Hybrid striped bass	cultured cultured	- -	$1.1912E^{-5}L^{3.007}$ $6.295E^{-6}L^{3.139}$	Brown & Murphy, 1991
Poor cod (<i>Trisopterus minutus capelanus</i>)	wild	6-24 cm	$0.005863L^{3.217}$	Politou & Papaconstantinou, 1991
<i>Oreochromis niloticus</i>	cultured	4-16 cm	$0.0501L^{2.75}$	Al-Asgah, 1992
<i>Hypostomus commersonii</i>	wild (M) (F)	7-39 cm	$0.01321L^{2.801}$ $0.1313L^{2.812}$	Goulart & Verani, 1992
Yellowtail (<i>Seriola quinqueradiata</i>)	cultured	1.9-15.7 cm	$0.00877L^{3.089}$ $0.00957L^{3.039}$ $0.01183L^{3.043}$	Safran, 1992
Yellowtail (<i>Seriola quinqueradiata</i>)	cultured (1 year) cultured (2 years)	- -	$0.006L^{3.33}$ $0.003L^{3.48}$	Garcia Gomez, 1993
Mediterranean Yellowtail (<i>Ser. dumerilii</i>)	cultured	< 330 g 330-375 g >375 g	$0.017L^{2.92}$ $0.035L^{2.74}$ $0.05L^{2.66}$	Garcia Gomez, 1993

1.1.2 CONDITION FACTOR - K

The analysis of weight-length data allows the determination of an index of growth commonly used, the condition factor (K). This index indicates the variation from the expected weight for length of individual fish or groups of individuals, as a measure of differences in fatness, changes in nutritional state or “well-being”, suitability of environment, gonad development, body shape, etc. (Le Cren, 1951).

The expression widely used is that represented as Fulton's condition factor, $K=(W / L^3) * 100$ (Le Cren, 1951), where W=weight (g) and L=length (cm).

This way of calculating the condition factor, as Craig (1977) points out, is adequate for a simple comparison, but must be based on the weight-length relationship to compare populations in time and space, so that any size of fish may be compared. For this purpose the condition factor has been determined as $K_r=(W / aL^b)$, where a is determined from the mean values of length and weight, and b is the slope of the pooled regression. This index is called relative condition factor (Le Cren, 1951). The relative condition factor (K_r) “is a measure of the deviation of a given fish from the mean weight-for-length for its size group” (Weatherley and Gill, 1989).

Among other variables, length itself, and any correlated factor, can affect the value of the condition factor, because most of the time the cubic law is not obeyed. However, this effect can be eliminated by the use of the relative condition factor (Le Cren, 1951). Gjerde (1989) assumed the cube law to calculate the condition factor, and when the b value was estimated it was significantly different from 3, implying that K was affected by length itself.

Table 1.2. shows some mean values of condition factor and relative condition factor, found in different species.

Table 1.2. Mean values of K and K_n in different species

SPECIES	ORIGIN	SIZE (cm)	K	K_n	SOURCE
Roach (<i>Rutilus rutilus</i>)	wild	7.2-23.0	2.01	-	Papageourgiou, 1979
Tilapia (<i>Tilapia zilli</i>)	cultured	3-12	-	1.01	Dadzie & Wangila, 1980
Carp (<i>Barbus grypus</i>)	wild	12.6-97.5	0.88	-	Al-Hakim <i>et al.</i> , 1981
Seabream (<i>Sparus aurata</i>)	wild	26	1.26	-	Eisawy & Wassef, 1984
	cultured	26	1.32	-	
Milkfish (<i>Chanos chanos</i>)	wild	9.2-18.6	0.87	-	Bagarinao & Thayaparan, 1986
Goatfish (<i>Mulloides flavolineatus</i>)	wild	12.6-25.2	0.975	-	Al-Absy, 1986-87
Rainbow trout (<i>Oncorhynchus mykiss</i>)	cultured	26.6	1.19	-	Barrera & Sañudo, 1987
Goatfish (<i>Parupneus cinnabarinus</i>)	wild	12.7-36.4	1.23	-	Al-Absy & Ajiad, 1988
Rainbow trout (<i>Oncorhynchus mykiss</i>)	cultured (1978)	59.9	1.41	-	Gjerde, 1989
	(1979)	58.6	1.66	-	
	(1980)	58.5	1.68	-	
Red seabream (<i>Pagrus major</i>)	cultured	28.2	3.036	-	Kora <i>et al.</i> , 1990
	wild	25.03	3.427	-	
Red seabream (<i>Pagrus major</i>)	cultured Korea	33.8	3.375	-	Tachibana <i>et al.</i> , 1992
	Korea	33.1	2.982	-	
	Japan	38.3	3.395	-	
Yellowtail (<i>Seriola quinqueradiata</i>)	cultured Korea	36.8	1.924	-	Tachibana <i>et al.</i> , 1992
	Japan	42.5	1.862	-	
Mediterranean Yellowtail (<i>S. dumerlii</i>)	cultured	21.6-26.5	1.27	-	Garcia Garcia <i>et al.</i> , 1993
		21.6-25.5	1.24	-	
Seabream (<i>Sparus aurata</i>)	wild	26.1	1.91	-	Sañudo <i>et al.</i> , 1993
	extensive	24.9	2.17	-	
	intensive	23.9	2.42	-	

A considerable number of variables can affect the value of the condition factor. Factors such as, age, sex, gonad cycles (maturation), availability of food, feeding habits, rate of feeding, production systems, seasonal changes and temperature, are some examples of sources of variation in the values of condition factor. The relative importance of each one of these factors will depend on the origin of the fish sampled, cultivated or natural stock.

1.1.3 OTHER PHYSIOLOGICAL INDICES

1.1.3.1 Hepatosomatic index - HSI

Fish store fat as the main source of energy. Such reserves are necessary for growth in sexually immature fish (Brett *et al.*, 1969) and for overwintering (Mustafa *et al.*, 1991), and in mature fish, for gonad maturation (Craig, 1977). The tissues where surplus energy accumulates differ from species to species. Energy can be stored as visceral depots (primary lipid storage sites), in muscle tissue or in the liver (Weatherley and Gill, 1989). Moreover, the relative importance of different sites and tissues in lipid storage depends on whether or not fish have been fed intensively on artificial diets.

Species, such as cod, *Gadus morhua* and haddock, *Melanogrammus aeglefinus*, store energy mainly in the liver (Love, 1980), while rainbow trout, *Oncorhynchus mykiss* (= *Salmo gairdneri*) (Weatherley and Gill, 1989), brown trout, *Salmo trutta*, and Arctic charr, *Salvelinus alpinus* (Jensen, 1980), store it as visceral fat, and plaice, *Pleuronectes platessa* L., store it in the muscle (Dawson and Grimm, 1980).

The relative size of liver should be correlated with the nutritional state of the fish and with growth rate. The indirect measure of growth is referred to as the Hepatosomatic index (HSI) and is expressed as, $HSI = (\text{Liver weight (g)} / \text{Body weight (g)}) * 100$ (Busacker *et al.*, 1990).

This index is often used in studies of yearly changes in growth of fish. Adams and McLean (1985), estimated growth in *Micropterus salmoides* using this index and other physiological variables (condition factor, viscerosomatic index and carcass-somatic index). Of these the hepatosomatic index was the best predictor of growth in immature fish. Mustafa *et al.* (1991) also noted the greater sensitivity of HSI compared with the condition factor, as an index of condition in overwintering of juveniles of seabass, *Dicentrarchus labrax*.

In cultured fish, the hepatosomatic index can be affected by several factors, such as, energy level, ration level, temperature and feeding frequency.

1.1.3.2 Gonadosomatic index - GSI

Fish tend to become mature at a particular length rather than at a particular age (Love, 1980). One way to account for the effect of body size on gonad size has been to represent gonad weight as a percentage of body weight (Delahunty and Vlaming, 1980). This relationship is represented by the Gonadosomatic index, $GSI = (\text{Gonad weight (g)} / \text{Body weight (g)}) * 100$.

In mature fish gonad weight increase with increasing in body weight, although this relationship changes during the year, depending on the stage of gonad development (Delahunty and Vlaming, 1980).

The dynamics of increasing gonad weight in proportion to body weight may vary between populations of the same species as well as between different species and also there is the possibility that GSI may change from year depending on environmental factors, such as food availability and temperature (Delahunty and Vlaming, 1980).

Besides the seasonal changes in gonad weight, there is also a difference in gonad size between sexes, the male gonad being generally smaller than that of the female (Love, 1980).

Gonad index can be used to distinguish between maturing and immature fish, although to distinguish accurately between immature and sexually maturing fish, measurement should take place late in the spawning season.

1.1.3.3 Viscerosomatic index - VSI, Visceral fat index and Gut index

As mentioned earlier, energy can be stored as visceral fat. Other indices have therefore been used to evaluate the condition or “well-being” of fish. Among these are Viscerosomatic

index (VSI), Visceral fat index (or intraperitoneal fat - IPF), and Gut-index. The weight of the various tissues and organs are expressed relative to whole body as indices, calculated as, Organ index (%)=(organ weight (g) / body weight (g)) * 100.

In salmonids, lipid deposits surrounding the viscera appear to be an important energy depot, and these reserves increase both in well-fed, rapidly growing fish and with increasing fish size. Nevertheless, the majority of the body lipid may be localised in eviscerated carcass (muscle) tissue (Miglav and Jobling, 1989). On the other hand, Corraze *et al.* (1993) studying three strains of rainbow trout, observed the presence of perivisceral adipose tissue only in the strain with the slowest growth.

Rainbow trout deposit a lot of abdominal fat and assuming a constant ratio of weight of gut to body weight, a high content of abdominal fat will cause a high viscerosomatic index (Gjerde, 1989).

Energy stored as lipid in the mesentery of the viscera is important primarily for long-term energy uses, such as over-winter basal metabolism and energy for gonad maturation (Adams and McLean, 1985).

In fish farming, the abdominal fat is a waste product. For this reason, it may be of importance to reduce the amount of fat deposited, as this may improve feed efficiency. Less abdominal fat may also be of importance from a marketing point of view, as some fish are sold ungutted (Gjerde and Schaeffer, 1989). The relative contribution of visceral fat to total fat is very important for processing yield (gutting, filleting). The development of fat in the flesh could play an important role not only in the visual appearance of the flesh and the processing yield but also taste (Fauconneau *et al.*, 1995).

Although body fat tends to increase with age, changes in the amount of fat are related to the nutritional history of the fish (Groves, 1970). Several studies have been carried out in such a way as to study the effect of some nutritional factors, ration size, feeding frequency, energy content, level of protein and lipids, on the amount of fat deposited in the abdominal cavity.

From the several factors studied, ration size and energy content seem to be the main factors responsible for fat deposition.

There is a trend towards greater fatness with increasing on age (Delahunty and Vlaming, 1980), which in sexually mature fish is a protection against excessive depletion at spawning periods, because there are several species that become more fecund as they grow larger (Love, 1980).

1.1.3.4 Dressing weight and Fillet weight

In addition to the physiological indices, the weight or percentage of fillet or dressing weight (carcass) are also used in biological studies of some species, mainly due to their importance from an economic point of view for aquaculture. The methodology employed in the determination of dressing weight is very variable, being sometimes difficult to compare results of different researchers, because it can be calculated with or without head, skin, kidneys and swim-bladder.

As a consequence of the progress of salmon farming in Norway, a higher feed efficiency has been achieved, which has led to an increase in the edible portion of salmon. More than 60% of the salmon comes as fillet (Åsgård *et al.*, 1995).

The several physiological indices are easy and rapid means of estimating growth and are also indicators of environmental conditions (including pollution), but their normal ranges must be determined as well as the influence of environmental factors on these indicators. A high correlation between any one of the indices and a biological feature, such as, body composition, may turn its use valuable in growth studies.

1.1.4 CRUDE COMPOSITION

The chemical body composition of an individual fish should characterise physiological condition, i.e., the nutritional status (Brett *et al.*, 1969), the reproductive stage and migratory behaviour (Marais, 1990). As pointed out by Brown and Murphy (1991), the physiological status determines the individual ability to compete successfully (through optimal foraging and reproduction), sustain growth, maintain and repair tissues and cope with stress induced by environmental changes.

As fish grow, changes occur in content of water (which greatly predominates), lipid, protein, carbohydrate (much smaller amounts), and minerals (frequently termed ash). Change in protein content is considered a measure of sustainable growth, although body protein is readily used as a source of energy during starvation. Lipids may be very transient body materials, but they are an important source of potential chemical energy, and their presence or absence reflects the physiological capacity of fish. Ash weight, may be the measurement least influenced by transient growth (Busacker *et al.*, 1990).

While patterns of growth for moisture and fat are common to all species, protein and ash content shows different patterns depending on species.

Generally, live-weight, whole body composition of fish is 70-80% water, 20-30% protein and 2-12% lipids. Extreme values for these components may, however fall outside these ranges (Brown and Murphy, 1991).

Crude composition can be affected by several factors, such as, size, age, energy level, ration size, feeding frequency and reproduction.

In the interpretation of body composition data, a careful distinction must be made between total gains and losses of constituents per animal and changes in concentration in individual tissues. As pointed out by Talbot *et al.* (1986), for example, the protein content of parr and kelts of Atlantic salmon, *Salmo salar*, appears very similar when expressed as g/kg,

however, when expressed per 10g Calcium (the most conservative component of the body), kelts have considerably less protein than parr.

The whole body composition is often used as an indication of the nutritional status of an animal, and is therefore an indirect index of growth rate, and also an indication of fish quality.

In the United States, farm-raised channel catfish, *Ictalurus punctatus*, is one of the most valuable aquaculture species, and there has been an increasing concern about product quality, particularly in the quantity and quality of lipid found in marketable fish. While protein content reaches a plateau value of 16-19% and keeps relatively constant, fat content is mainly controlled by diet (Fauconneau *et al.*, 1995). Excess fat in cultured channel catfish results in decreased dress-out yields and a shorter shelf-life of processed fish. Therefore reduced lipid deposition has generally considered to be desirable (Stowell and Gatlin III, 1992; Webster *et al.*, 1992a).

As pointed out by Fauconneau *et al.* (1995), in a review of growth and meat quality relations in carp, the involvement of lipid content in flesh quality is not clear and depends on local customs. In some countries, lipids are less important than other compounds (protein), especially for taste in products based on raw or cooked meat. In other countries, a minimum lipid content would be required for both texture and taste of flesh.

As Groves (1970) stated, "for sockeye salmon, *Oncorhynchus nerka*, fat tends to increase with body size but it is much more closely a function of the nutritional history of the fish". Fatness in fishes, has been shown to be influenced by size, age, feeding practices, diet composition, etc.

In immature rainbow trout, even under conditions that produce great differences in growth rates, neither the relative size of tissues nor the proportions of the major chemical components, related to body weight, are much disrupted. Both chemical constituents and

tissues increase in an orderly manner that bears a constant relation to body weight (Weatherley and Gill, 1989).

1.2 INTERDEPENDENCIES

Methods of estimating the magnitude of body components are of potential value for fisheries science and aquaculture because they permit ready calculations of body component values, by the use of body parameters that can be readily obtained in the field which are otherwise tedious to determine.

The general equations to predict one element from the other, have been obtained by the use of least squares linear, $y=a + bx$ or exponential, $y=ax^b$ regressions, or by the least squares linear regressions of the logarithmically transformed data, $\log y=\log a + b \log x$.

Because there are dynamic interdependencies among protein, lipid, moisture and ash, with reciprocal relationships as an unavoidable consequence, and also because it is expensive and time-consuming to make large-scale determinations, biologists have tried to seek empirical evidence of interrelationships among these components, that would define and codify interdependent changes.

The very specific nature of the interrelationship of various body constituents, has led to the determination of regression equations by which body fat, protein and ash, can be calculated from a knowledge of body water content alone. Brett *et al.* (1969) were the first to develop regression equations for the calculation of body protein and fat in young sockeye salmon, *Oncorhynchus nerka*, assuming a ash content to be 2% of wet weight.

Table 1.3. shows some regression equations representing this relationship in several species. All the equations showed very high correlation between the parameters.

Table 1.3. Regression equations showing the interrelationship between biochemical components, in some species

SPECIES	REGRESSION EQUATIONS (%)	SOURCE
Sockeye salmon (<i>Oncorhynchus nerka</i>)	Fat = 50.95 - 0.59 Water Protein = 50.53 - 0.459 Water	Brett <i>et al.</i> , 1969
Sockeye salmon (<i>Oncorhynchus nerka</i>)	Protein = 0.204 Water ^{1.038}	Groves, 1970
Perch (<i>Perca fluviatilis</i>)	Male Protein = 36.031130 - 0.283223 Water Female Protein = 44.04182 - 0.399434 Water	Craig, 1977
Rainbow trout (<i>Oncorhynchus mykiss</i>)	Lipid = 0.8024 Protein ^{1.227} Lipid = 70.82 - 0.83 Water	Weatherley and Gill, 1983b
<i>Oligosarcus jenynsi</i>	Protein = 0.213166Water ^{1.051} Ash = -68.581 + 61.728Water	Juárez, 1985
Yamato carp Mirror carp (<i>Cyprinus carp</i>)	Moisture = 80.7 - 0.88Crude Fat Moisture = 82.5 - 1.40Crude Fat	Shimma, 1986
Hybrid yamato x Mirror carp	Moisture = 80.3 - 0.66 Crude Fat	Shimma and Maeda, 1986
Yellowtail (<i>Seriola quinqueradiata</i>)	Crude lipid = 57.8 - 0.794 Water	Date and Yanamoto, 1988
Striped bass Hybrid striped Bass	Crude Fat = 165.206 - 1.968Water Crude Protein = -23.564 + 1.141Water Ash = -48.775 + 0.902Water Crude Fat = 108.106 - 1.215Water Crude Protein = 11.440 + 0.642Water Crude Ash = -30.186 + 0.694Water	Brown and Murphy, 1991
Red seabream (<i>Pagrus major</i>)	Body Water = 76.30 - 0.856Body Fat	Tsuchimoto <i>et al.</i> , 1992

Estimates of body constituents from moisture or dry matter are easy and rapid, although there are situations where it is not possible to determine water content. In these cases body weight, length and indices of condition that can be easily and quickly determined, may be used to predict body composition. Equations showing some of these relationships are presented in table 1.4..

Table 1.4. Regression equations showing the interrelationship between body traits and body composition, in some species

SPECIES	REGRESSION EQUATIONS	SOURCE
Sockeye Salmon (<i>Oncorhynchus nerka</i>)	Water (%) = 0.00571Length ^{3.118} Protein (%) = 0.000579Length ^{3.417}	Groves, 1970
Perch (<i>Perca fluviatilis</i>)	Energy = 0.880902 + 4.029492K	Craig, 1977
<i>Oligosarcus jenynsi</i>	Wet weight = 0.204E ⁻⁴ Length ^{2.980} Dry weight = 0.0239E ⁻⁴ Length ^{3.154} Water (%) = 0.198E ⁻⁴ Length ^{2.920} Protein (%) = 0.243E ⁻⁵ Length ^{3.069}	Juárez, 1985
Red seabream (<i>Pagrus major</i>)	Weight visceral part/length = -4.576 + 0.234K Weight muscle part/length = -0.352 + 0.715K Fat visceral part (%) = -94.83 + 4.191K Lean mass/length = -1.75 + 0.727K	Kora <i>et al.</i> , 1990

The good correlation between organs and tissues, and body weight, allow the determination of regression equations to predict, approximately the weight of each organ from a simple measurement as the body weight (Weatherley and Gill, 1983a; Barrera and Sañudo, 1987).

JAPANESE SPECIES



Fig.1 - 3 kg yellowtail, *Seriola quinqueradiata*



Fig.2 - 1.5 kg amberjack, *Seriola purpurascens*

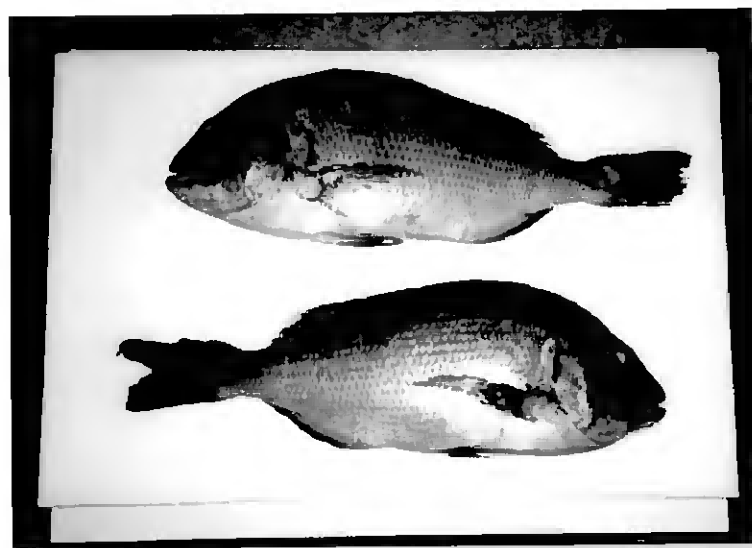


Fig.3 - 1.8 kg red seabream, *Pagrus major*

EUROPEAN SPECIES

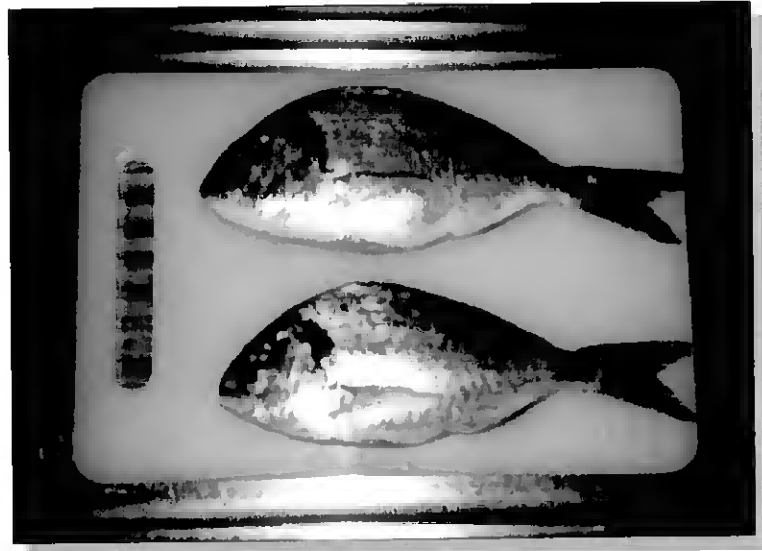


Fig.4 - 350-400 g seabream, *Sparus aurata*

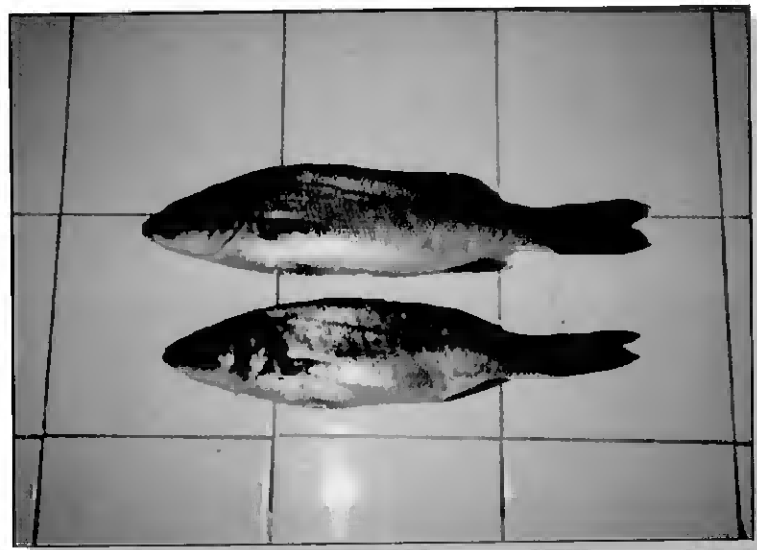


Fig.5 - 200-300 g seabass, *Dicentrarchus labrax*

2 MATERIALS AND METHODS

2.1 FISH AND SAMPLING

All the species studied in this work were collected from farming sites, where the fish had been raised under standard commercial conditions. The intention was to cover all the size ranges normally found in the grow out phase of aquaculture of the different species. Nevertheless, only same sizes were analysed.

2.1.1 JAPANESE SPECIES

The Japanese species yellowtail (*Seriola quinqueradiata*) (fig.1), amberjack (*Seriola purpurascens*) (fig.2) and red seabream (*Pagrus major*) (fig.3) were cultured in the southwestern part of Japan. In this region the annual variation of sea water temperature is between 15 and 29°C. Moist and extruded pellets were used to feed the yellowtail (2.0-2.5 kg of body weight ⇒MP; 3.5-5.5 kg of body weight ⇒EP) and the amberjack (1.5 kg of body weight ⇒EP; 2.0-2.5 kg of body weight ⇒MP), while the red seabream was fed only with moist pellets.

In Norway, at Nutreco ARCLab (Aquaculture Research Centre Laboratory), all the measurements and analyses were done on the Japanese species (yellowtail, amberjack, red seabream). For this purpose the fish had to be sent frozen to Norway from Japan. The fish were killed by a blow to the head. After cooling, the fish were put into plastic bags in styrofoam boxes and frozen at -18°C. The boxes were marked with the project number and box number. Additional information was added to the boxes, 1) the place where the fish was farmed; 2) the size of the fish; and 3) what feed the fish had been fed. Before shipping dry ice was added.

The yellowtail (*Seriola quinqueradiata*) and amberjack (*Seriola purpurascens*) used in this study were sexually immature. Some of the red seabream (*Pagrus major*) had already reached and surpassed the maturity size, although they were not mature.

2.1.2 EUROPEAN SPECIES

The European species, seabream (*Sparus aurata*) (fig.4) and seabass (*Dicentrarchus labrax*) (fig.5) were collected from a fish farm - TIMAR - in Algarve, southern Portugal. The variation of sea water temperature is between 11 and 13°C in winter and 22 and 25°C in summer. For this species dry pellets were used as feed.

For the European species (seabass and seabream), part of the work was done in Portugal at the University of Algarve, particularly concerning the biological measurements and moisture content, and the remaining biochemical analyses were done in Norway, at Nutreco ARCLab. Thus the same procedures were used for all the species. The European species were killed by placing them in freezing water, and then they were put into plastic bags and frozen at -20°C.



The seabream (*Sparus aurata*) used in this study were sexually immature, while some of the seabass (*Dicentrarchus labrax*) had reached and surpassed the maturity size, although they were not mature.

2.2 IDENTIFICATION OF THE SPECIES

Each species was divided into categories of weight for a better identification of the fish. The fish were identified first with a letter corresponding to the species, then the category of weight to which they belonged and finally the number of the fish (ex: Y10-1, Yellowtail, category 10, fish number 1). For the categories where the fillet was separated from the rest, a letter F (fillet) or R (rest) was added to the last number (ex: Y10-1F or Y10-1R).

The number of fish sampled, the size ranges (until harvest size) and the categories used are indicated in table 2.1.

Table 2.1. Number of fish, size ranges and categories per species

Size category	Size range (g) and number of fish analysed within each size category (n)				
	Yellowtail	Amberjack	Red seabream	Seabream	Seabass
1					<150 (15)
2				< 250 (15)	151-250 (15)
3				251-350 (15)	251-350 (15)
4				351-450 (15)	351-450 (15)
5				451-550 (15)	451-550 (15)
(...)					
9	750-1249 (3)				
10	1250-1749 (7)	1250-1749 (11)	625- 874 (1)		
11	1750-2249 (9)	1750-2249 (7)	875-1049 (6)		
12	2250-2749 (7)	2250-2749 (1)	1050-1149 (3)		
13	2750-3249 (9)		1150-1249 (2)		
14	3250-3749 (7)		1250-1349 (1)		
15	3750-4249 (7)		1350-1449 (1)		
16	4250-4749 (7)		-		
17	4750-5249 (1)		1550-1649 (1)		
18			1650-1749 (1)		
19			1750-1849 (4)		
20			1850-1949 (5)		
21			1950-2050 (5)		
Total # of fish	57	19	30	60	75

2.3 MEASUREMENTS AND CALCULATED INDICES

2.3.1 ROUND WEIGHT

After defrosting, the round weight was measured (Sartorius Universal U6100) to the nearest 1 g in the Japanese species and to the nearest 0.1 g in the European species.

2.3.2 FORK LENGTH

The fork length, measured from the tip of the snout to the tip of the shortest median ray of the tail fin, was registered to the nearest 1 mm (ichthyometer).

2.3.3 CONDITION FACTOR

The length-weight relationship was determined using the equation $W=aL^n$ (Le Cren, 1951). The logarithmic transformation produces a straight line described by $\log W=\log a + b \log L$, where a and b can be estimated by regression. This permits the calculation of the relative condition factor $K_r=W / aL^b$ (Le Cren, 1951). The Fulton's condition factor was also calculated, $K=(W / L^3)*100$.

2.3.4 DRESSED WEIGHT

After weighing and measuring the fork length, the fish were gutted. The dressed weight was measured inclusive of the head, heart and kidneys. It was measured (Sartorius Universal U6100) to the nearest 1 g in the Japanese species and to the nearest 0.1 g in the European species.

The percentage of dressed weight was calculated as:

$$\% \text{ Dressed weight} = (\text{Dressed weight (g)} / \text{Total weight (g)}) * 100$$

2.3.5 WEIGHT OF TOTAL VISCERA, LIVER, GONADS, GUT, VISCERAL FAT

The total viscera included all the internal organs, except heart and kidneys. The gut (stomach+intestine) was evacuated by squeezing before weighing. From the initial viscera weight and that of the squeezed gut the stomach content was determined.

In the species red seabream (*Pagrus major*), seabream (*Sparus aurata*) and seabass (*Dicentrarchus labrax*) the visceral fat was easily separated from the rest of the visceral organs, because it was found in the abdominal cavity as a distinct tissue. In yellowtail

(*Seriola quinqueradiata*) and amberjack (*Seriola purpurascens*) it was not possible to separate the visceral fat because this tissue was found covering the pyloric caecae only.

The weights of total viscera, liver, gonads, gut and visceral fat were registered to the nearest 0.01 g (Mettler PM 4800 Delta Range).

All the visceral organs were replaced in the visceral cavity for further analysis of crude composition of the whole fish.

With the respective weight of each visceral organ the following indices were calculated:

Viscerosomatic index - VSI = ((Viscera weight - stomach content)(g) / Total weight (g))*100

Hepatosomatic index - HSI = (Liver weight (g) / Total weight (g))*100

Gonadosomatic index - GSI = (Gonads weight (g) / Total weight (g)) *100

Gut index = (Gut weight (g) / Total weight (g))*100

% Visceral fat = (Visceral fat weight (g) / Total weight (g))*100

2.3.6 WEIGHT OF FILLET AND REST (everything except the fillet)

For those fish that weighed more than 500 g, one fillet was removed, which was possible only in the yellowtail, amberjack and red seabream. The fillet from left side was removed and weighed to the nearest 1 g (Sartorius Universal U6100).

The percentage of fillet was calculated as:

$$\% \text{Fillet} = 2 * (\text{Fillet weight (g)} / \text{Total weight (g)}) * 100$$

The fillet and the rest (everything except the fillet) of the fish were weighed, ground and homogenised separately. Aliquots were taken for determination of content of moisture, ash, fat and protein. The total crude composition of the whole fish was calculated by addition.

The seabass and seabream, weighed less than 500 g, so the whole fish were ground and homogenised, and the same procedures as had been used for the other fish were used to analyse the crude composition.

2.4 CHEMICAL ANALYSES

The methods of analysis for crude composition were made following the standard procedures of the ARCLab (Aquaculture Research Centre Laboratory).

2.4.1. MOISTURE

For the determination of moisture content, a sample of 25-30 g (to the nearest 0.01 g, in a Mettler PM 4600 Delta Range) was dried in an oven (Termaks), to a constant weight at 103 degrees Celsius during 40 h. The water content in the sample was calculated from the loss of sample weight. The percentage of water was expressed as a percentage of wet weight.

$$\% \text{ Moisture} = ((W_2 - W_3 / W_2 - W_1)) * 100$$

W_1 = weight of empty dish (g)

W_2 = weight of dish + sample before drying (g)

W_3 = weight of dish + sample after drying (g)

After the determination of moisture, the dried sample was ground and then used to analyse the content of protein, fat and ash.

2.4.2 FAT

The quantitative analysis of fat content in fish was determined using the Soxtec method. In a sample weighing approximately 1 g (between 1.0-1.5 g in a Mettler AT 200) the fat was extracted with dichloromethane during heating (Soxtec System HT 1043 extraction unit and Soxtec System HT 1046 service unit, Tecator). The dichloromethane was evaporated

and the fat content was determined by weighing. The percentage of total lipids was expressed as a percentage of wet weight.

$$\% \text{ Fat} = ((W_3 - W_2) / W_1) * 100$$

W_1 = weight of sample (g)

W_2 = weight of clean extraction cup (g)

W_3 = weight of the extraction cup with fat (g)

2.4.3 CRUDE PROTEIN

The crude protein content of fish was analysed using the Kjeldahl method. Raw protein was determined as Kjeldahl-nitrogen multiplied by a protein factor, which for bioproducts is commonly set to 6.25. A sample of 0.4 g (+/- 0.0003 g in a Mettler AT 200) was digested (Digestion System 1015 Digester, Tecator) in sulphuric acid to convert organic nitrogen to ammonia, which was then held as ammonium sulphate. The solution was titrated and distilled and the acid-neutralised concentration of ammonia was measured. Distillation and titration, after adding excess NaOH, was done in the Kjeldahl auto (Tecator, 1030 analyser). The percentage of water was expressed as a percentage of wet weight. The percentage of protein was read directly from the display, from which calculation was done according to the expression:

$$\% \text{ Protein} = 14.01 * M * f * (\text{ml titran} - \text{ml blank}) / \text{sample (mg)}$$

14.01 = atomic weight of nitrogen

M = molarity of the acid (mole / ml)

f = Kjeldahl factor 6.25

Titran = reagent

Blank = distilled water

2.4.4 ASH

A muffle furnace (Nabertherm) set at 540 degrees Celsius was used to combust samples of 4 g (nearest 0.01 g in a Mettler AT 200) for 16 h and estimate ash content. The ash in the sample was calculated from the change in sample weight. Ash weight was expressed as a percentage of wet weight.

$$\% \text{ Ash} = ((W_3 - W_1) / (W_2 - W_1)) * 100$$

W_1 = weight of empty diegel (g)

W_2 = weight of diegel + sample before burning (g)

W_3 = weight of diegel + sample after burning (g)

All the biochemical analyses were done in duplicate.

2.5. STATISTICAL ANALYSES

Statistical analyses were carried out using either the software package UNISTAT or STATISTICA 4.5.

A T-test was performed to:

- determine whether round weight varies significantly with stomach content and gonad weight;
- compare the relative condition factor with the Fulton's condition factor;
- determine the influence of sex on all other parameters.

Regression analyses (least squares linear regressions and multiple regression) were used to investigate the relationship of tissue indices and crude composition to whole body weight. The least squares linear regressions of the logarithmically transformed data was applied to the study of the length-weight relationship.

3 RESULTS

3.1 BODY TRAITS

The T-test performed to determine whether round weight varies significantly with the stomach content and gonad weight, showed no significant effect ($p>0.05$) of these variables on total weight, in all species.

The influence of sex on all the analysed parameters was slightly different between species. Seabream (*Sparus aurata*) was not considered because this species is a protandric hermaphrodite, changing to female only after the first sexual maturation of the testes, which occurs at approximately, the 30 cm (± 2 years), under suitable environmental conditions. Since fish from the present study were less than 30 cm, and as macroscopic analyses indicated, they all were considered as being immature males.

In amberjack (*Seriola purpurascens*), red seabream (*Pagrus major*) and yellowtail (*Seriola quinqueradiata*), sex differences were present with respect to gonad weight ($p<0.01$) and GSI ($p<0.01$).

In seabass (*Dicentrarchus labrax*), beyond the differences in gonad weight and GSI ($p<0.01$), sex also influenced other parameters, such as, total weight ($p<0.01$), length ($p<0.01$), dressed weight ($p<0.01$), liver weight ($p<0.05$), gut weight ($p<0.01$) and total viscera ($p<0.05$).

Because of these results, total weight including the stomach content and gonad weight, and pooled data for both sexes, for each species were used for the further studies.

The mean and standard deviation of the several body traits, studied by species, are presented in the tables 3.1 and 3.2. Table 3.1., shows the biological measurements and indices, and table 3.2. the biochemical composition, in the Japanese and European species.

3.1.1 BIOLOGICAL MEASUREMENTS AND INDICES

3.1.1.1 Length-weight relationship and condition factor

Table 3.3. shows the length-weight relationship, in the Japanese and European species studied in the present work, where it is possible to observe that all species have allometric growth, which means that $b \neq 3$.

Table 3.3 Length-weight relationship

SPECIES	$W = a L^b$	r	p - level
Yellowtail (<i>Seriola quinqueradiata</i>)	$W = 0.001146 L^{3.65593}$	0.98174	$p < 0.01$
Amberjack (<i>Seriola purpurascens</i>)	$W = 0.07787 L^{2.62037}$	0.94282	$p < 0.01$
Red seabream (<i>Pagrus major</i>)	$W = 0.02863 L^{2.93625}$	0.98667	$p < 0.01$
Seabream (<i>Sparus aurata</i>)	$W = 0.01537 L^{3.13088}$	0.98214	$p < 0.01$
Seabass (<i>Dicentrarchus labrax</i>)	$W = 0.00873 L^{3.13592}$	0.99343	$p < 0.01$

From the analysis of length-weight data, the determination of the parameters a and b , allowed the calculation of the relative condition factor. The values of condition factor and relative condition factor for each species are represented in table 3.1

The T-test used to compared these two different expressions of condition, showed a highly significant difference ($p < 0.01$) between them in all the species.

3.1.1.2 Percentage of dressed weight and total weight

The percentage of dressed weight found in the present work (table 3.1), shows high values for all the species.

Yellowtail, seabream and seabass, showed a significant decrease ($p < 0.01$) in the percentage of dressed weight, while for amberjack and red seabream that trend was not significant.

Fig. 6 shows the relationship between total weight and percentage of dressed weight, with the respective regression coefficient and regression parameters.

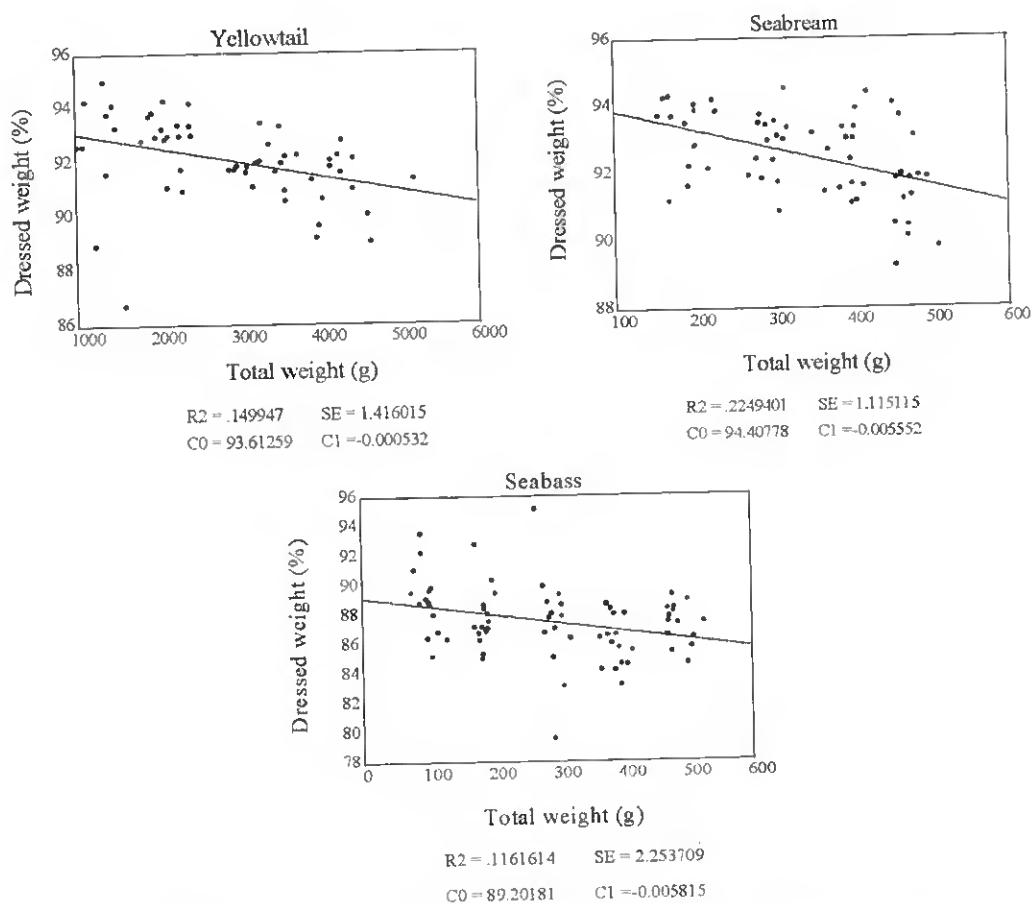


Figure 6. The relationship between total body weight (g) and percentage of dressed weight (%) in farmed yellowtail, seabream and seabass

Nevertheless, in those fish where the fillet was removed, it was possible to observe an increase in the proportion of fillet with body weight, although this increase was only significant for yellowtail ($p < 0.05$) (fig. 7).

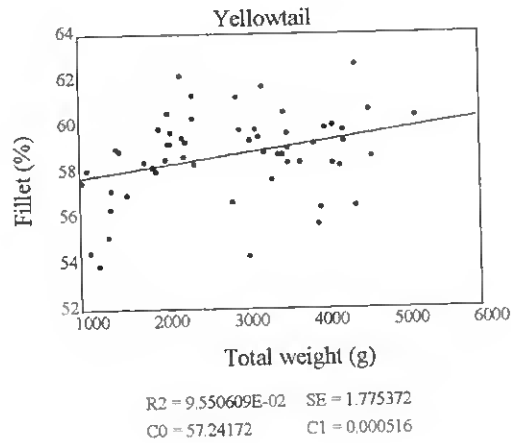


Figure 7. The relationship between total body weight (g) and percentage of fillet (%) in farmed yellowtail

3.1.1.3 Viscerosomatic index and total weight

The increase in the viscerosomatic index with body weight in yellowtail, seabream (fig. 8a,b) and seabass (fig. 8c), ($p < 0.01$), was the responsible for the decrease in the percentage of dressed weight in these species. For amberjack and red seabream, VSI didn't change significantly with body size.

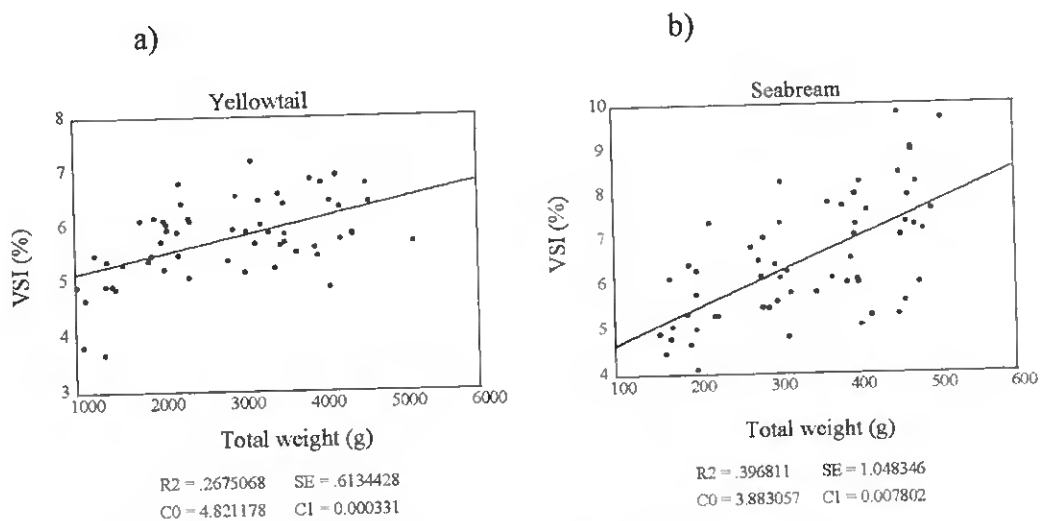


Figure 8a, b. The relationship between total body weight (g) and viscerosomatic index (%) in farmed yellowtail and seabream

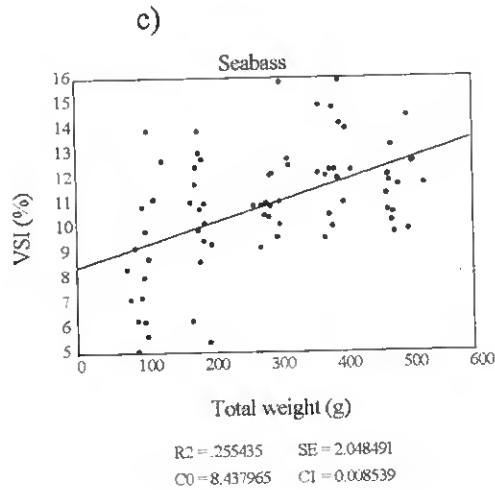


Figure 8c. The relationship between total body weight (g) and viscerosomatic index (%) in farmed, seabass

3.1.1.4 Percentage of gut, liver and visceral fat and total weight

The percentage of gut (stomach+intestine) decreased significantly with increasing fish weight in red seabream (fig. 9b), seabream and seabass (fig. 9c, d) ($p < 0.01$). In amberjack, gut percentage did not change significantly with body weight, but in yellowtail the percentage of gut increased (fig. 9a), ($p < 0.01$) with increasing fish weight.

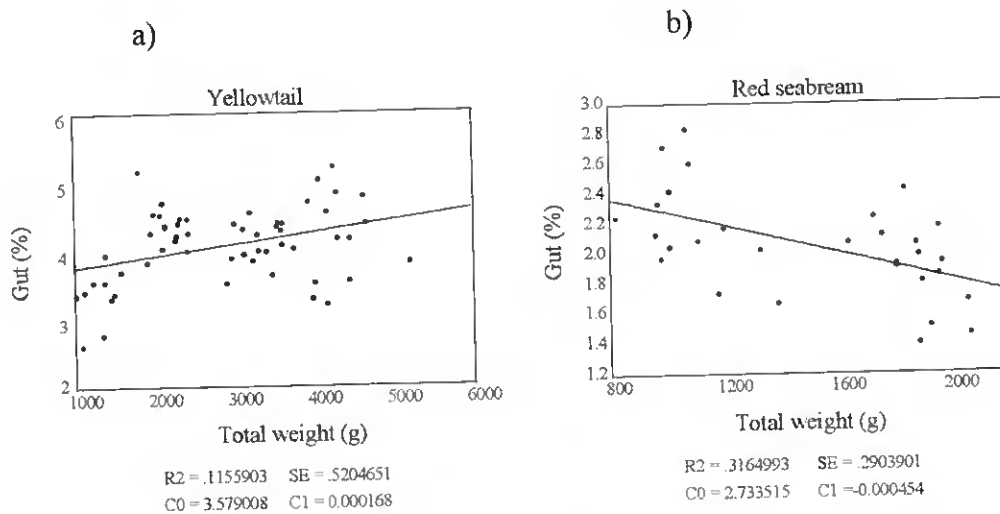


Figure 9a, b. The relationship between total body weight (g) and percentage of gut (%) in farmed yellowtail and red seabream

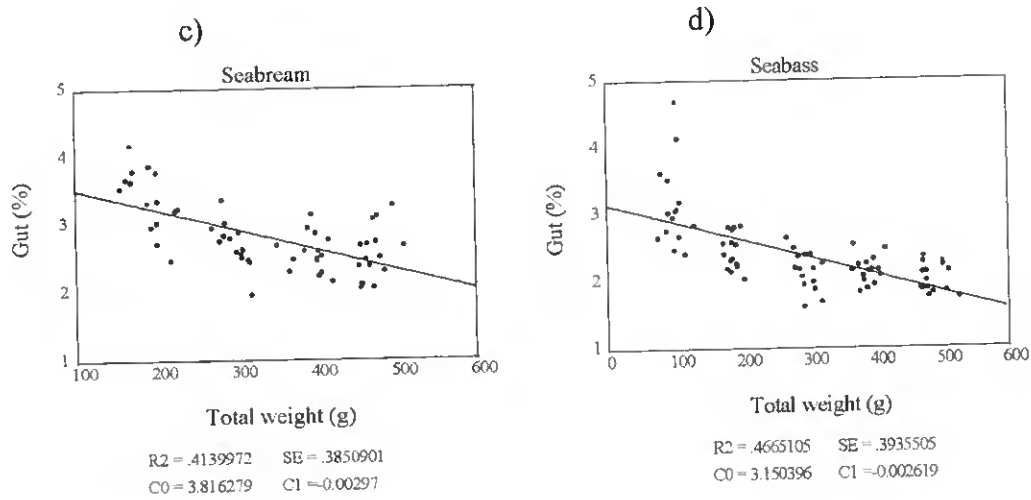


Figure 9c, d. The relationship between total body weight (g) and percentage of gut (%) in farmed seabream and seabass

Red seabream presented a decrease in HSI with body weight (fig. 10b), ($p < 0.01$). A significant increase in HSI with body weight was only observed in yellowtail and seabream (fig. 10a, c), ($p < 0.01$).

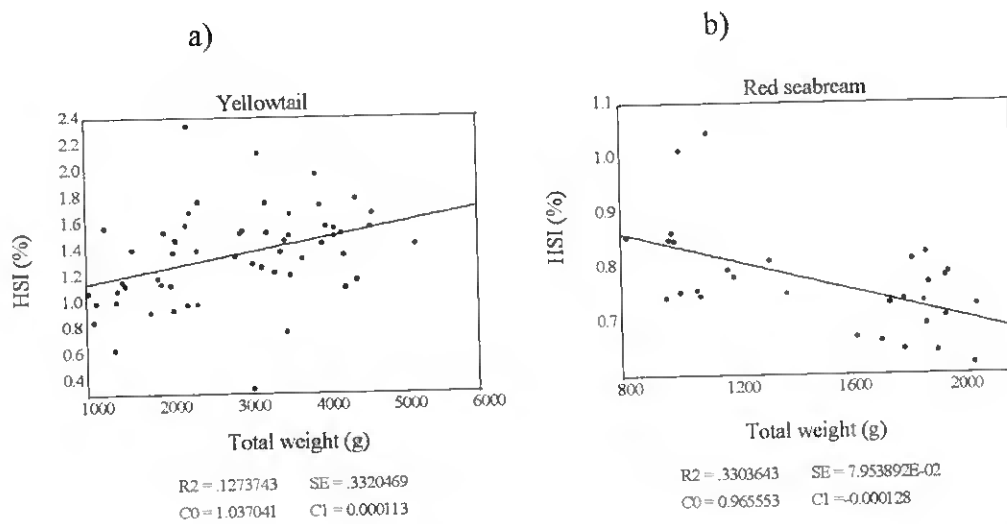


Figure 10a, b. The relationship between total body weight (g) and hepatosomatic index (%) in farmed yellowtail and red seabream

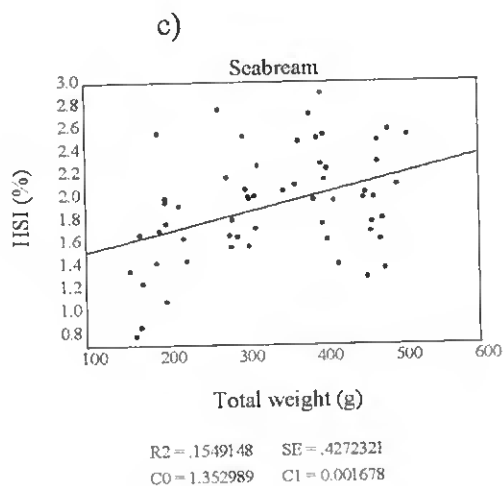


Figure 10c. The relationship between total body weight (g) and hepatosomatic index (%) in farmed seabream

As was mentioned in chapter 2.3., it was not possible to dissect the mesenteric fat, in yellowtail and amberjack, but in red seabream, seabream and seabass, since mesenteric fat formed a separated tissue, this fat was easily dissected and weighed.

The increase in visceral fat with increasing body weight, was significant for seabream and seabass ($p < 0.01$) (fig. 11), and not significant for red seabream.

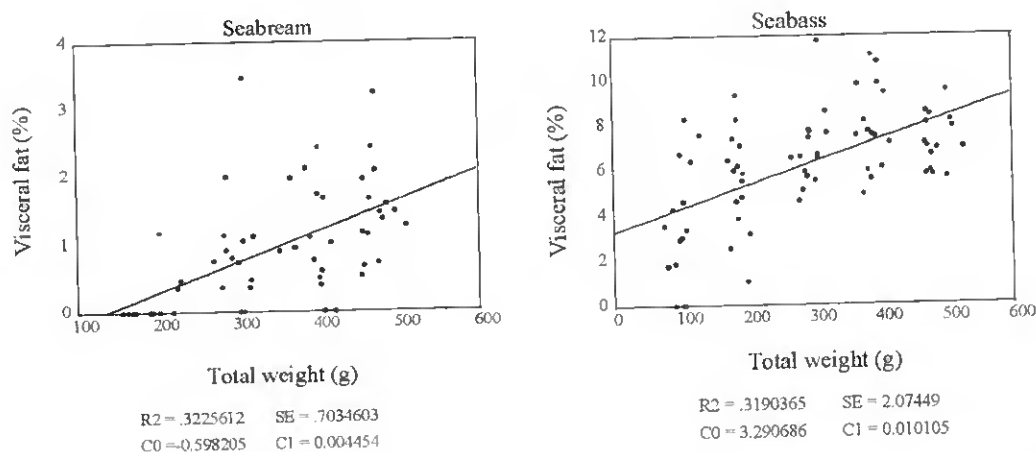


Figure 11. The relationship between total body weight (g) and percentage of visceral fat (%) in farmed seabream and seabass

3.1.2 CHEMICAL COMPOSITION

Table 3.2. shows the mean values of body composition found for the Japanese and European species.

3.1.2.1 Moisture content and total weight

A lower proportion of moisture content with increasing body size, can be observed in yellowtail, seabream, seabass ($p < 0.01$), and amberjack ($p < 0.05$) (fig. 12). No significant effect was observed in red seabream.

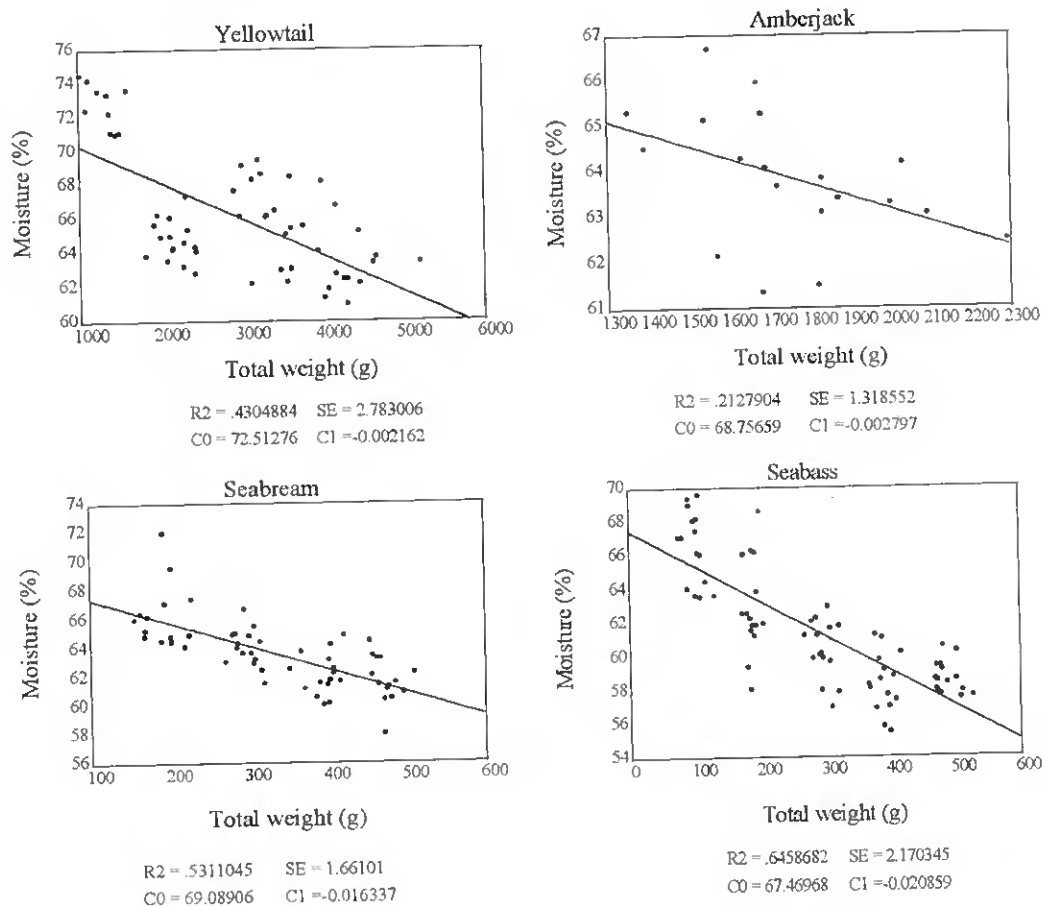


Figure 12. The relationship between total body weight (g) and moisture content in the whole fish (%) in farmed yellowtail, amberjack, seabream and seabass

The same trend was seen in the fillet, but it was highly significant only for yellowtail ($p < 0.01$) (fig. 13).

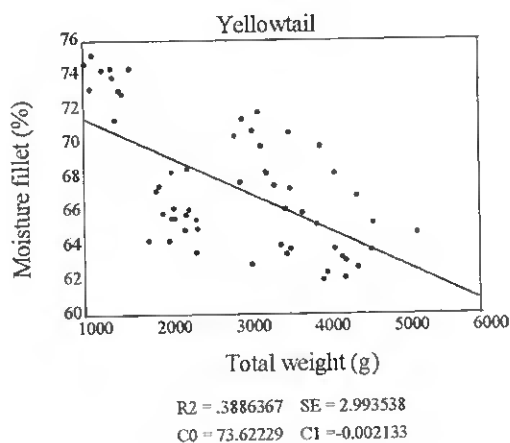


Figure 13. The relationship between total body weight (g) and moisture content in the fillet (%) in farmed yellowtail

3.1.2.2 Fat content and total weight

A highly significant positive effect was obtained for yellowtail, seabream (fig. 14a, b) and seabass ($p < 0.01$) (fig. 14c). For amberjack and for red seabream it was not significant, although the latter species showed a relatively constant amount of fat.

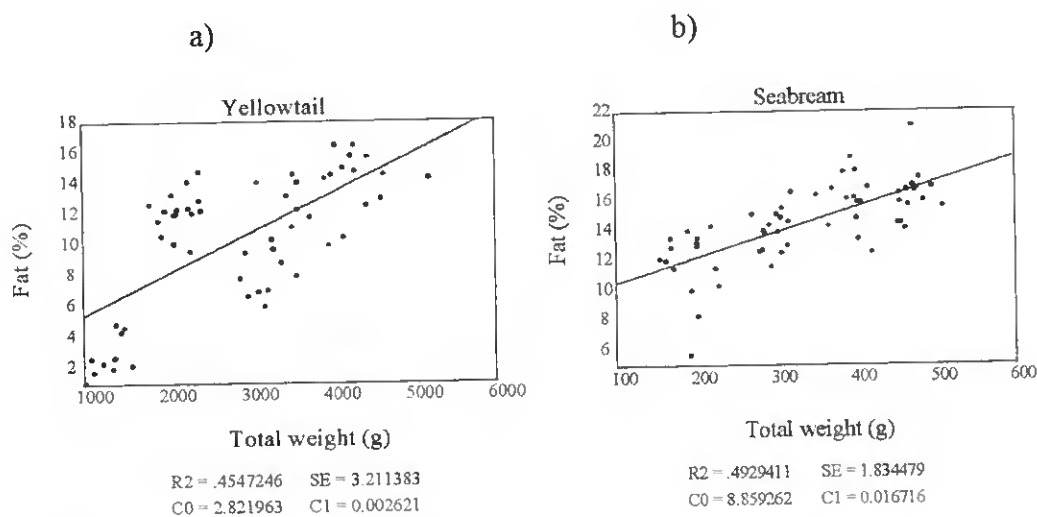


Figure 14a, b. The relationship between total body weight (g) and fat content in the whole fish (%) in farmed yellowtail and seabream

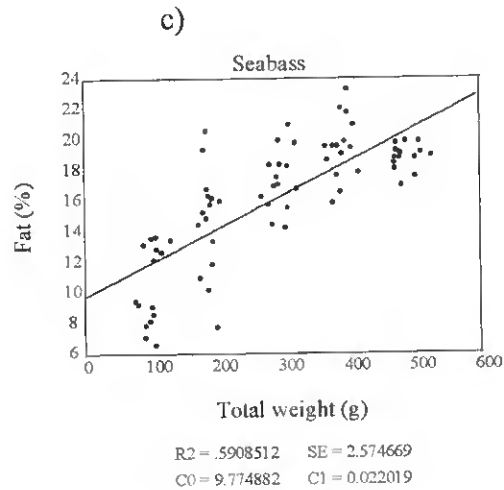


Figure 14c. The relationship between total body weight (g) and fat content in the whole fish (%) in farmed seabass

As with the values for moisture, yellowtail was the only species which showed a significant increase in fat content in the fillet ($p < 0.01$) (fig. 15). The same trend could be seen in amberjack, while red seabream showed a decrease in fat content in the fillet, but neither of these results were significant.

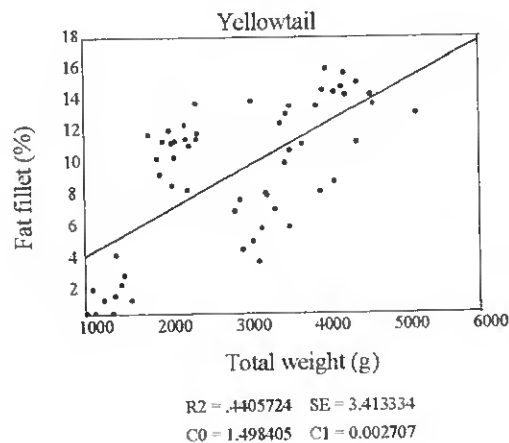


Figure 15. The relationship between total body weight (g) and fat content in the fillet (%) in farmed yellowtail

3.1.2.3 Moisture content and fat content

A highly significant inverse relationship, could be observed in all species ($p < 0.01$).

3.1.2.4 Protein content and total weight

Yellowtail showed a significant ($p < 0.01$) decrease in protein with total weight. This decrease was seen both in the whole fish (fig. 16) and in the fillet (fig. 17).

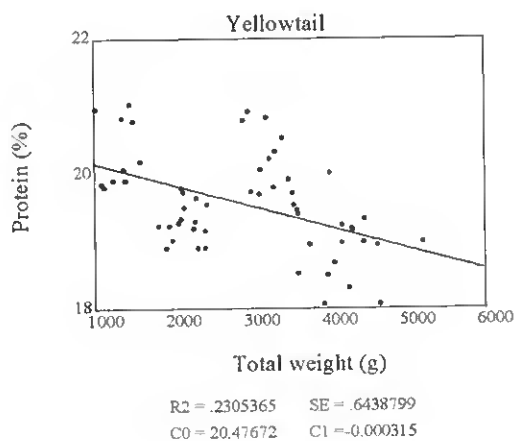


Figure 16. The relationship between total body weight (g) and protein content in the whole fish (%) in farmed yellowtail

The other species showed a slight increase in protein content with body size, although this relationship was not significant, except for the fillet of red seabream ($p < 0.01$) (fig. 17).

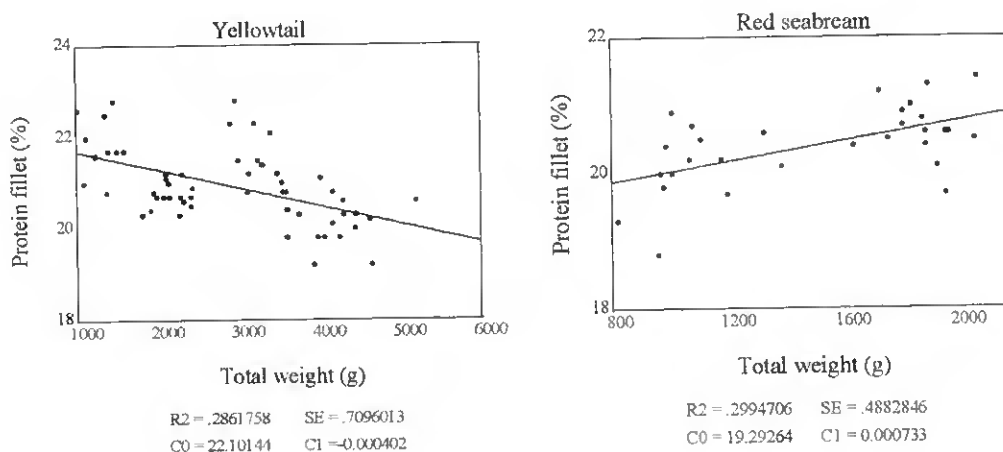


Figure 17. The relationship between total body weight (g) and protein content in the fillet (%) in farmed yellowtail and red seabream

3.1.2.5 Ash content and total weight

Ash content decreased with increasing total weight. This relationship was significant for yellowtail, seabream and seabass, in the whole fish ($p < 0.01$) (fig. 18), and for yellowtail and amberjack in the fillet ($p < 0.05$) (fig. 19).

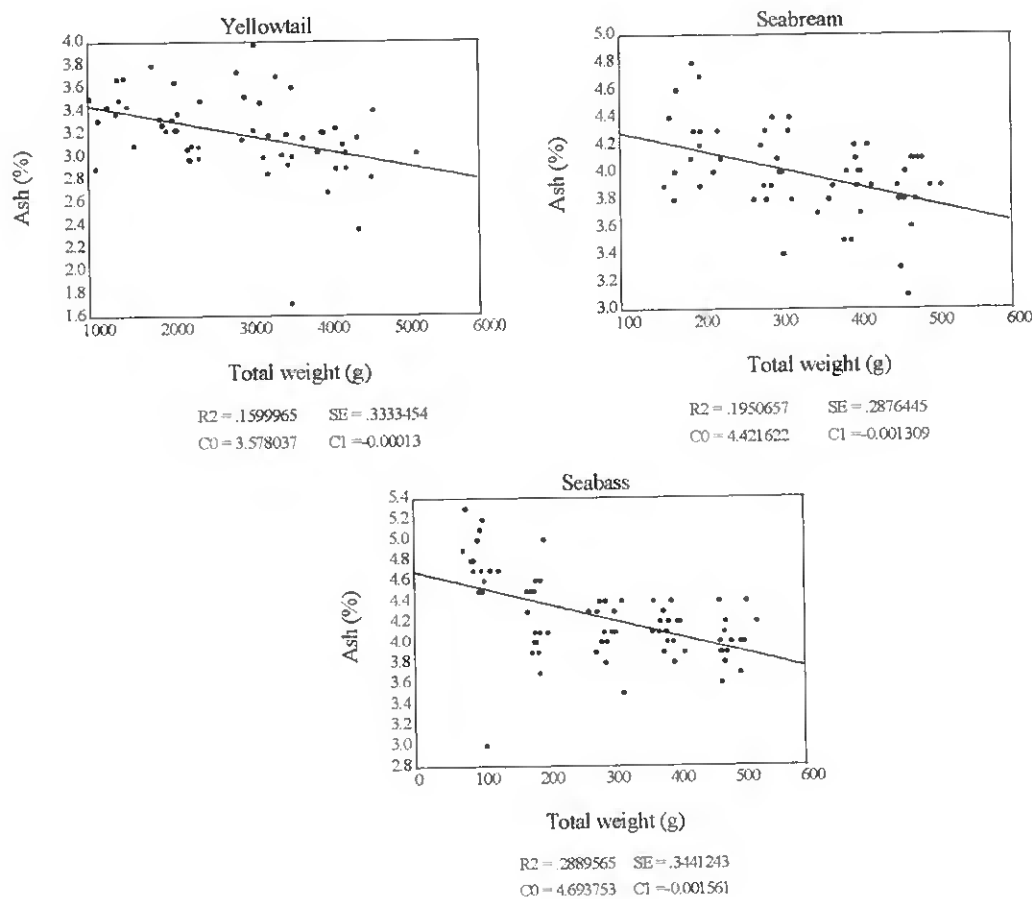


Figure 18. The relationship between total body weight (g) and ash content in the whole fish (%) in farmed yellowtail, seabream and seabass

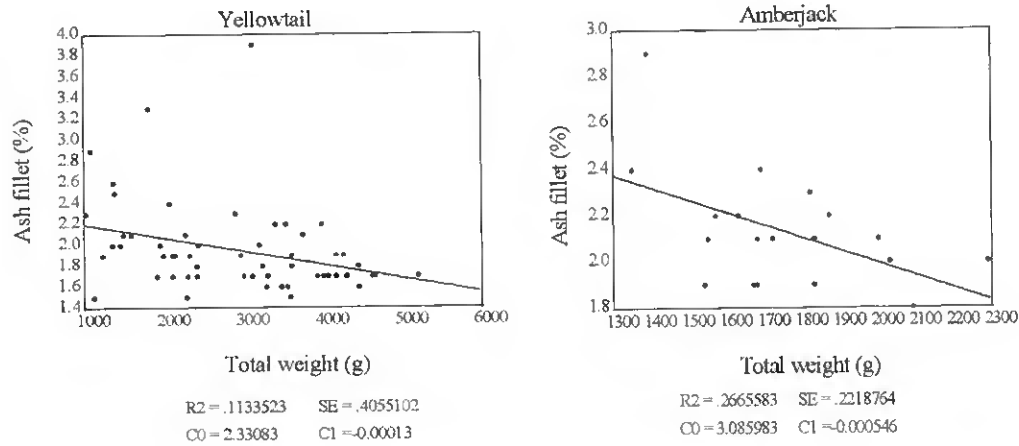


Figure 19. The relationship between total body weight (g) and ash content in the fillet (%) in farmed yellowtail and amberjack

3.1.3 REGRESSION EQUATIONS

Table 3.4 shows the regression equations which allow the determination of weight of organs and tissues, with a high degree of accuracy, from a simple measurement, such as, total weight or moisture in the case of fat content.

All the regression equations show a significance level of 1%, except percentage of fillet and percentage of ash in fillet for yellowtail, and percentage of moisture for amberjack, both with a significance level of 5%.

Table 3.4. Regression equations of organs and tissues and body composition for the Japanese and European species

SPECIES	REGRESSION EQUATIONS Y(%) = a + b Weight (g) or Moisture (%)	r ²	p - level
Yellowtail (<i>Seriola quinqueradiata</i>)	Dressed weight = 93.61259 - 0.000532 W	0.149947	p < 0.01
	VSI = 4.821178 + 0.000331 W	0.267506	"
	HSI = 1.037041 + 0.000113 W	0.127374	"
	Gut = 3.579008 + 0.000168 W	0.115590	"
	Fillet = 57.24172 + 0.000516 W	0.095506	p < 0.05
	Moisture = 72.51276 - 0.002162 W	0.430488	p < 0.01
	Moisture fillet = 73.62229 - 0.002133 W	0.388636	"
	Fat = 2.821963 + 0.002621 W	0.454724	"
	Fat fillet = 1.498405 + 0.002707 W	0.440572	"
	Protein = 20.47672 - 0.000315 W	0.230536	"
	Protein fillet = 22.10144 - 0.000402 W	0.286175	"
	Ash = 3.578037 - 0.00013 W	0.159996	"
	Ash fillet = 2.33083 - 0.00013 W	0.113352	p < 0.05
Fat = 75.22597 - 0.970449 Moisture	0.885391	p < 0.01	
Amberjack (<i>Seriola purpurascens</i>)	Moisture = 68.75659 - 0.002797 W	0.212790	p < 0.05
	Ash fillet = 3.085983 - 0.000546 W	0.266558	"
	Fat = 83.17937 - 1.099153 Moisture	0.938675	p < 0.01
Red seabream (<i>Pagrus major</i>)	HSI = 0.965553 - 0.000128 W	0.330364	p < 0.01
	Gut = 2.733515 - 0.000454 W	0.316499	"
	Protein fillet = 19.29264 + 0.000733 W	0.299470	"
	Fat = 64.09206 - 0.805206 Moisture	0.455298	"
Seabream (<i>Sparus aurata</i>)	Dressed weight = 94.40778 - 0.005552 W	0.224940	p < 0.01
	VSI = 3.883057 + 0.007802 W	0.396811	"
	HSI = 1.352989 + 0.001678 W	0.154914	"
	Gut = 3.816279 - 0.00297 W	0.413997	"
	Visceral fat = -0.598205 + 0.004454 W	0.322561	"
	Moisture = 69.08906 - 0.016337 W	0.531104	"
	Fat = 8.859262 + 0.016716 W	0.492941	"
	Ash = 4.421622 - 0.001309 W	0.195065	"
Fat = 80.42188 - 1.036901 Moisture	0.953180	"	
Seabass (<i>Dicentrarchus labrax</i>)	Dressed weight = 89.20181 - 0.005815 W	0.116161	p < 0.01
	VSI = 8.437965 + 0.008539 W	0.255435	"
	Gut = 3.150396 - 0.002619 W	0.466510	"
	Visceral fat = 3.290686 + 0.010105 W	0.319036	"
	Moisture = 67.46968 - 0.020859 W	0.645868	"
	Fat = 9.774882 + 0.022019 W	0.590851	"
	Ash = 4.693753 - 0.001561 W	0.288956	"
Fat = 83.1295 - 1.090355 Moisture	0.976038	"	

3.2 AQUACULTURE ASPECTS

The multiple regression used to relate two independent variables, the condition factor and total weight, with those parameters of interest to the aquaculturist, can be shown using a 3D scatter plot. These graphics allows the rapid and easily visualisation of the production level of a certain parameter from easy measurements, such as weight and length.

3.2.1 YELLOWTAIL (*Seriola quinqueradiata*)

Yellowtail has been the most intensively cultured fish in Japan and accounts for about 70% of total cultured fish production. After a two year period of culturing, fed with moist or dry pellets, yellowtail weighs about 5 kg, which is the preferred market size (Honma, 1993).

In the analysed sample it is possible to observe in figure 20, that for a given weight, as the condition factor increases, the percentage of dressed weight decreases ($r^2=0.2166476$, $p<0.01$). For instance, a fish with 3000 g and a condition factor of 1.25, has a dressed weight of 94%, but if a fish with the same weight, has a condition factor of 1.6, then the percentage of dressed weight decreases to about 92%.

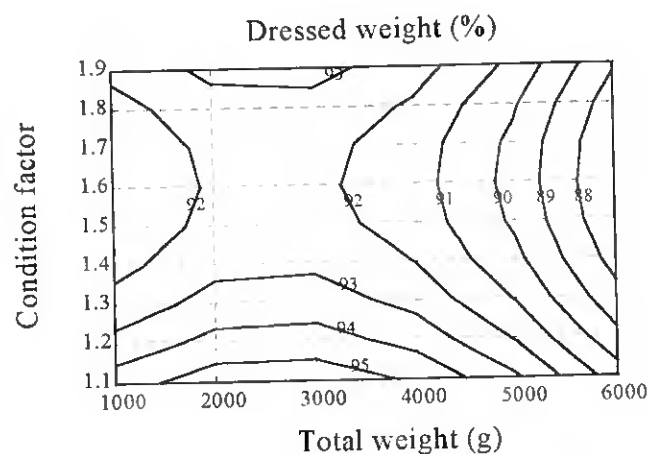


Figure 20. The relationship between total body weight (g), condition factor and percentage of dressed weight (%) in farmed yellowtail

A 3000 g fish with a condition factor of 1.25 has a VSI of 5%, while one with a condition factor of 1.6 has 6% of VSI ($r^2=0.4506043$, $p<0.01$) (fig. 21).

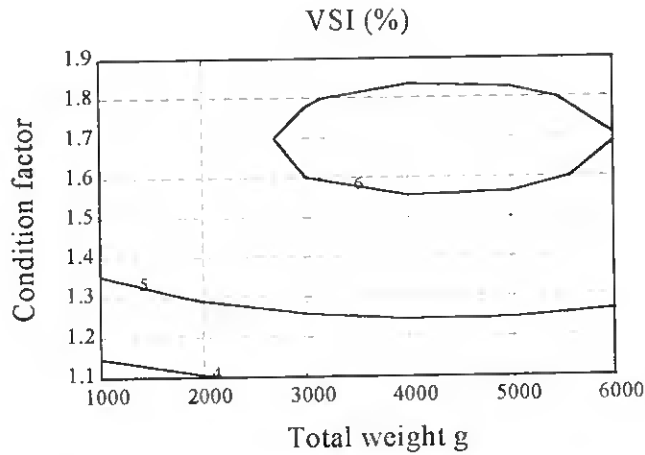


Figure 21. The relationship between total body weight (g), condition factor and viscerosomatic index (%) in farmed yellowtail

Although with a lower proportion of carcass in the whole body, fish in better condition have a greater proportion of fillet (fig. 22). The graph shows a 56.5% of fillet for a fish with 3000 g and a condition factor of 1.25, and 58.8% of fillet for a fish with the same weight but with a condition factor of 1.6 ($r^2=0.242418$, $p<0.01$).

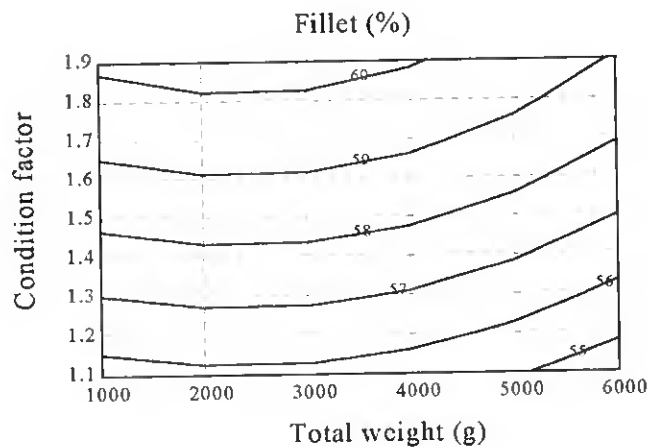


Figure 22. The relationship between total body weight (g), condition factor and percentage of fillet (%) in farmed yellowtail

As the condition factor of yellowtail increases the fat content in the whole fish (fig. 23, $r^2=0.773112$) or in the fillet (fig. 24, $r^2=0.7503384$) also increases ($p<0.01$). And, obviously, the moisture content decreases, due to the inverse relationship between these two body constituents.

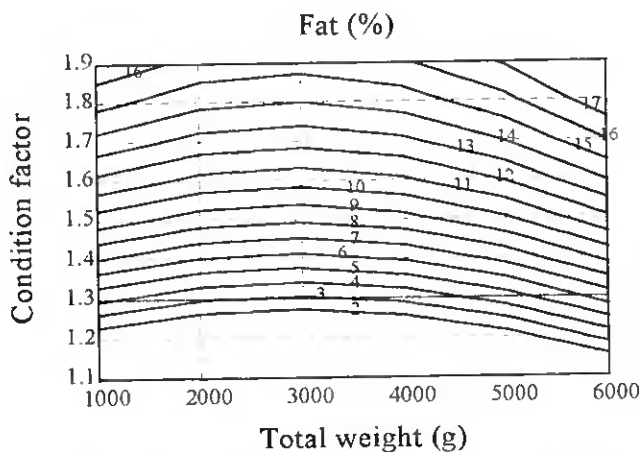


Figure 23. The relationship between total body weight (g), condition factor and percentage of fat (%) in farmed yellowtail

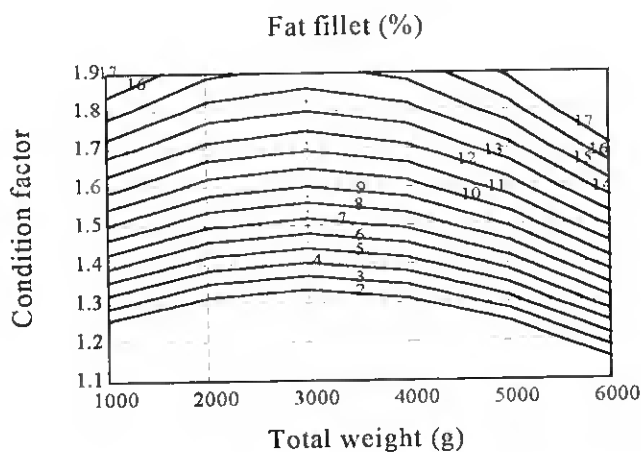


Figure 24. The relationship between total body weight (g), condition factor and percentage of fat in the fillet (%) in farmed yellowtail

For a 3000 g fish with the higher condition factor (1.6), almost half (50 %) of the fat content can be found in the muscle, while in a fish with lower condition (1.25) only 25% of the total fat is found in the muscle ($r^2=0.678794$, $p<0.01$) (fig. 25).

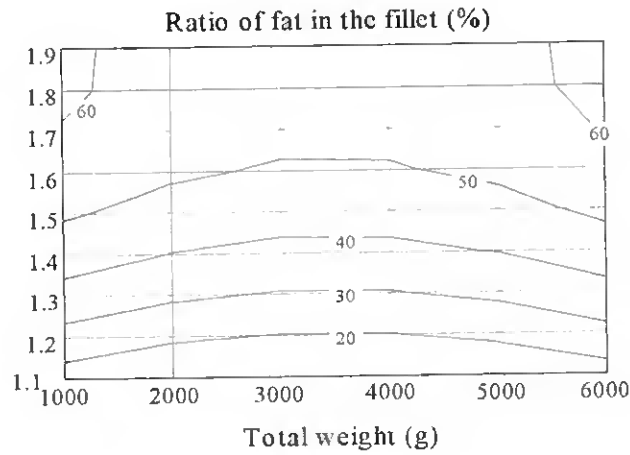


Figure 25. The relationship between total body weight (g), condition factor and ratio of fat in the fillet (%) in farmed yellowtail

Variations in the condition factor, also have some effect in the percentage of protein in the fillet (fig. 26). A lower proportion of protein, around 21%, is found in the muscle of a 3000 g fish with a condition factor of 1.6, compared with a fish with a condition of 1.25, that in this case has 22.5% of protein ($r^2=0.4693277$, $p<0.01$).

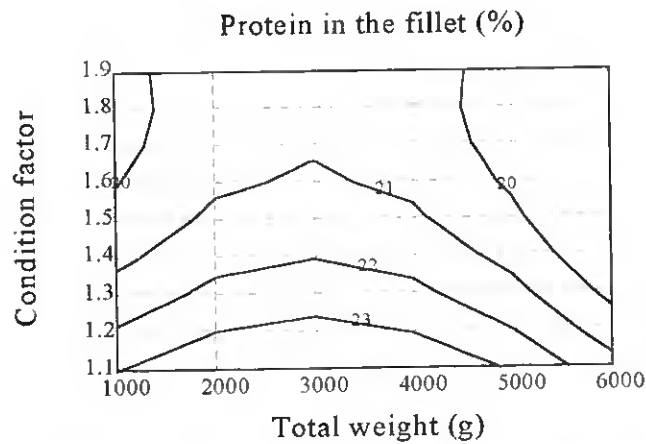


Figure 26. The relationship between total body weight (g), condition factor and percentage of protein in the fillet (%) in farmed yellowtail

3.2.2 AMBERJACK (*Seriola purpurascens*)

The decline in yellowtail prices resulted in a decrease in its farming activity, which led to more aquaculturists farming other species. Amberjack is a new marine species now being considered for aquaculture in Japan (Honma, 1993).

Special care should be taken in the interpretation of the results for this species, because a “switch” in the trends of the different parameters occurred, when the condition factor reached 1.8-1.9.

The decrease in the percentage of dressed weight with the increase of condition factor, for a fish of the same weight, is also present for this species, but only until a condition factor of 1.9 (fig. 27). For instance, for a fish of 1700 g with a condition factor of 1.65, the dressing percentage is approximately 96%, while for a fish with a condition factor of 1.9, the dressing percentage is 94% ($r^2=0.2965869$, $p<0.05$). Above a $K=1.9$, the dressing percentage starts to increase.

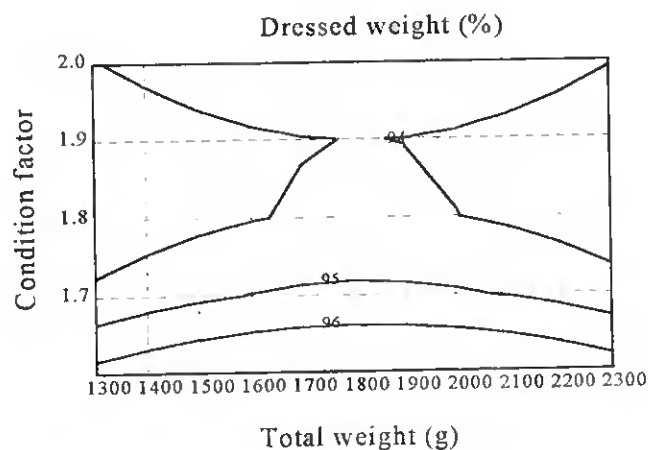


Figure 27. The relationship between total body weight (g), condition factor and percentage of dressed weight (%) in farmed amberjack

The opposite trend is observed in the relationship between VSI and condition. The fish with the highest condition (1.9) shows also the highest VSI of 5.3-5.4%, while the fish with the

lowest condition (1.65) shows a VSI lower than 4.2% ($r^2=0.2574879$, $p<0.05$). A decrease in VSI is observed above a condition factor of 1.9 (fig. 28).

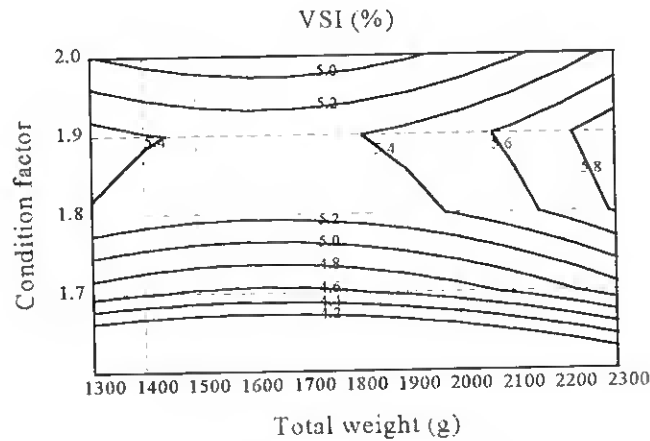


Figure 28. The relationship between total body weight (g), condition factor and viscerosomatic index (%) in farmed amberjack

While in yellowtail it was possible to observe an increase in the proportion of the fillet with the increase in condition factor, for amberjack that proportion decreases until a condition factor of 1.8, beyond which starts to increase (fig. 29). A 1700 g fish has a percentage of fillet, of near, 61% with a condition factor of 1.8, and approximately 63.5% with a condition of 1.65. With a condition factor of 1.9, percentage of fillet is around 61.1%, which means that above that value of condition this proportion increased ($r^2=0.5071989$, $p<0.01$).

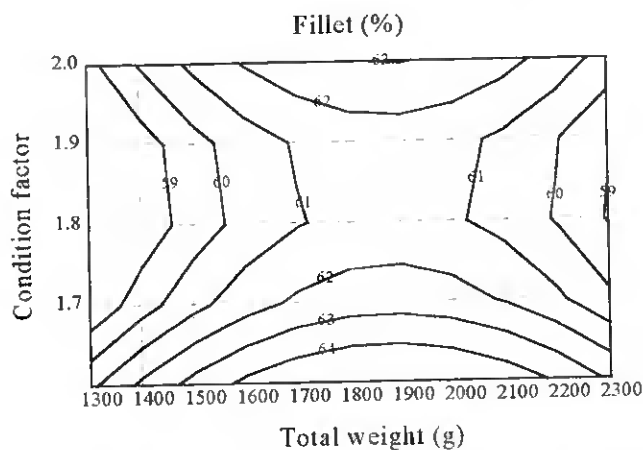


Figure 29. The relationship between total body weight (g), condition factor and percentage of fillet (%) in farmed amberjack

In amberjack the fat content in the whole fish decreases slightly with the increase in condition factor, although only below a condition of 1.8, because above this value it increases. These trends in the percentage of fat in the fillet were not significant.

Fig. 30, shows that for a total weight of 1700 g, there are slight differences in fat content among fish with 1.65, 1.8 and 1.9 of condition factor, with 14%, 12.8% and 13.1% fat, respectively ($r^2=0.2308667$, $p<0.05$). Once more, it is possible to observe that 1.8 is the point where there is a reversal of the trends.

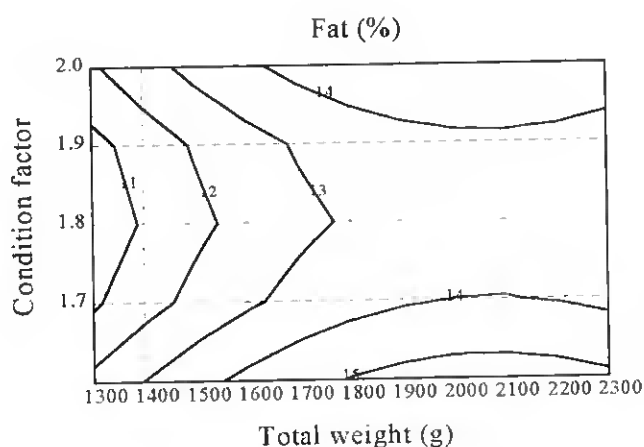


Figure 30. The relationship between total body weight (g), condition factor and percentage of fat (%) in farmed amberjack

The increase in the fat content in the whole fish, can be observed through the increase in the proportion of total fat that is deposited in the fillet, only above a condition factor of 1.8 (fig. 31). In this case, a fish (1700 g) with 1.8 of condition factor has deposited 53-54% of fat in the muscle, while a fish with 1.9 of condition has deposited approximately 54.4% of fat in the muscle ($r^2=0.259165$, $p<0.05$). Below 1.8 the opposite situation occurs, fat deposition in the muscle decreaseing with increasing condition. A fish which $K=1.6$ has more than 60% of fat deposited in the muscle.

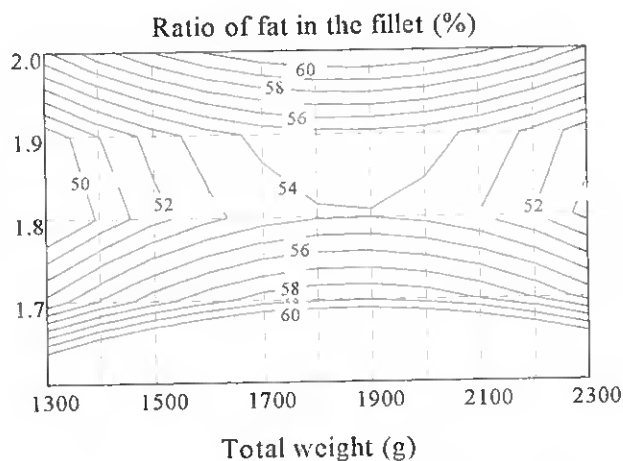


Figure 31. The relationship between total body weight (g), condition factor and ratio of fat in the fillet (%) in farmed amberjack

3.2.3 RED SEABREAM (*Pagrus major*)

After yellowtail, red seabream is the second most commonly cultured marine fish in Japan. In 30 months, fed with moist pellets, red seabream reaches the marketable size of 1.2 to 1.5 kg (Foscarini, 1988; Honma, 1993).

For this species only the relationship between total weight and condition factor with percentage of dressed weight and VSI, were significant. Once more, a decrease in the proportion of carcass with an increase in condition factor were observed (fig. 32). A 1600 g fish with a condition factor of 2.1 has a percentage dressed weight of 93%, while a fish with a condition factor of 2.3 has between 91-92% of dressed weight ($r^2=0.2047354$, $p<0.05$).

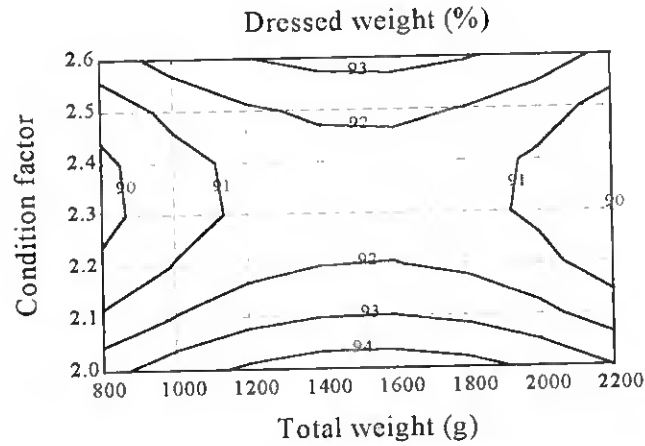


Figure 32. The relationship between total body weight (g), condition factor and percentage of dressed weight (%) in farmed red seabream

The decrease in the percentage of dressed weight is compensated for by the increase in VSI (fig. 33). The same fish shows a 7-8% of VSI for the highest condition factor and around 6 % of VSI for the lowest condition ($r^2=0.2007427$, $p<0.05$).

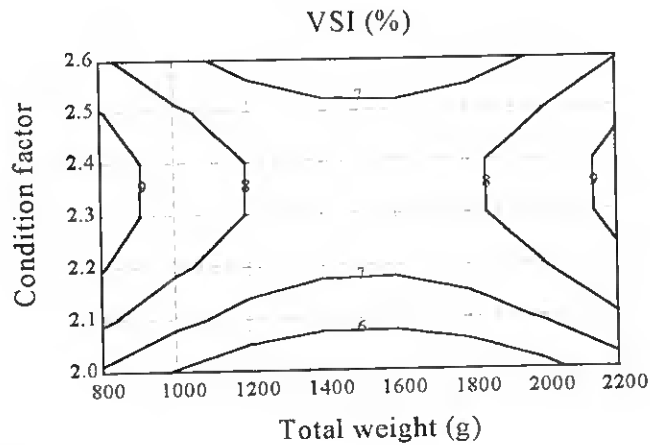


Figure 33. The relationship between total body weight (g), condition factor and viscerosomatic index (%) in farmed red seabream

The remaining relationships were not statistically significant, although it was possible to observe, for a fish with the same weight, a trend toward a decrease in percentage of fillet, in the percentage of fat in the whole fish and in the fillet, a decrease in the proportion of total fat deposited in the fillet and an increase in the percentage protein content in the fillet, with increasing condition factor.

3.2.4 SEABREAM (*Sparus aurata*)

The seabream is a highly prized food fish found in Mediterranean seas. Fish is grown to a commercial size of 350-400 g, fed with dry pellets, which can take over 18 months.

In seabream a variation in condition factor, induces a very slight modification in the percentage of dressed weight (fig. 34). A fish of 400 g with a condition factor of 2.3 has a slightly higher percentage of dressed weight (92.4%) than a fish with 2.5 of condition (92.1%) ($r^2=0.2753557$, $p<0.01$).

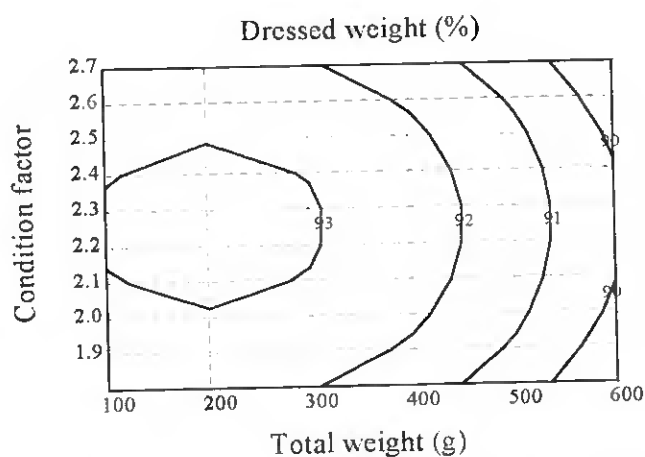


Figure 34. The relationship between total body weight (g), condition factor and percentage of dressed weight (%) in farmed seabream

Nevertheless, the fish with the lowest condition factor have a little lower VSI (6.8%), compared with the one with the highest condition (7.2%) ($r^2=0.4219103$, $p<0.01$) (fig.35).

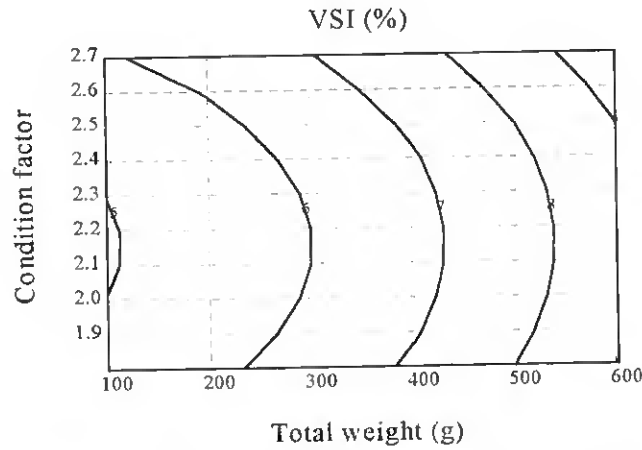


Figure 35. The relationship between total body weight (g), condition factor and viscerosomatic index (%) in farmed seabream

This is because, this fish has less proportion of visceral fat (1.1%), than the fish with the best condition (1.4%) ($r^2=0.3868267$, $p<0.01$) (fig. 36).

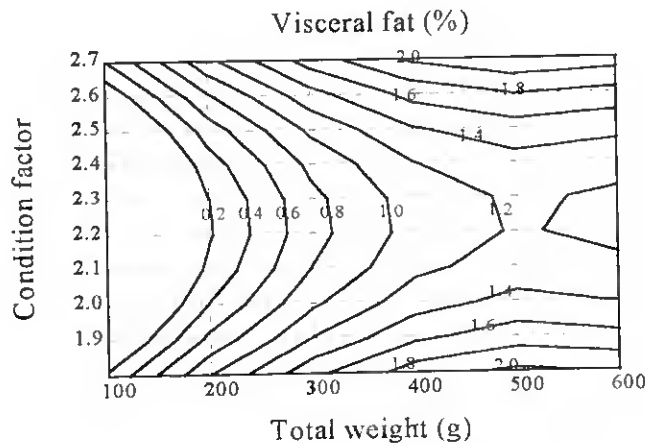


Figure 36. The relationship between total body weight (g), condition factor and percentage of visceral fat (%) in farmed seabream

Even with a small variation in visceral fat, fat content increases with condition factor (fig. 37). A 400 g fish with a low condition factor (2.3) has about 15% fat, while a fish with high condition factor (2.5) has more than 16% ($r^2=0.5847237$, $p<0.01$).

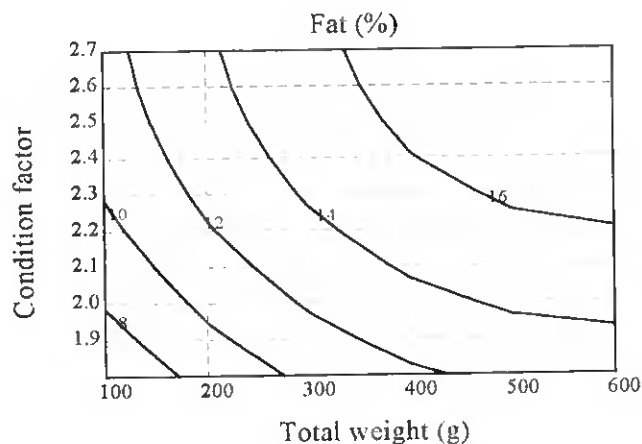


Figure 37. The relationship between total body weight (g), condition factor and percentage of fat (%) in farmed seabream

3.2.5 SEABASS (*Dicentrarchus labrax*)

Seabass is another highly prized species cultivated in the Mediterranean area. Seabass reach a commercial size of 300-400 g, fed with dry pellets, in approximately 2 years.

In seabream, unlike seabass, the increase in condition factor, is accompanied by a marked decrease in the percentage of dressed weight (fig. 38). A 300 g fish shows almost 89% of dressed weight, with a condition factor of 1.2, and less than 87% of dressed weight when the condition factor increases to 1.4 ($r^2=0.2589898$, $p<0.01$).

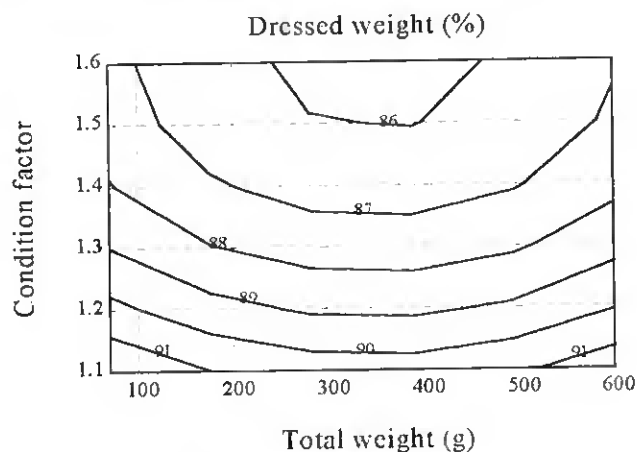


Figure 38. The relationship between total body weight (g), condition factor and percentage of dressed weight (%) in farmed seabass

Naturally associated with this decrease, is the increase with condition of the VSI (fig.39). The same fish has, respectively, approximately 11% and 12% of VSI ($r^2=0.3482052$, $p<0.01$).

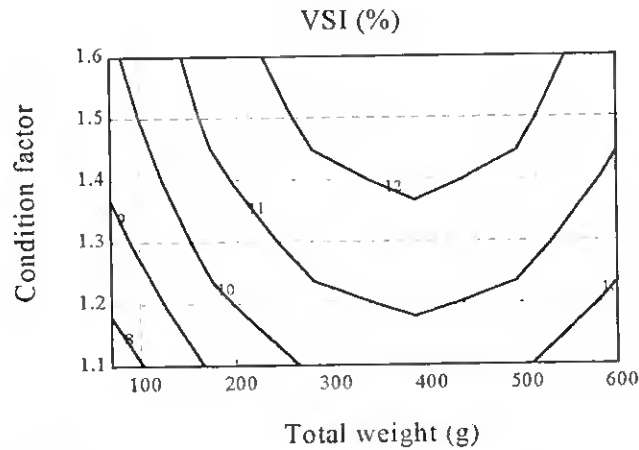


Figure 39. The relationship between total body weight (g), condition factor and viscerosomatic index (%) in farmed seabass

Fish with the highest condition factor have the highest percentage of visceral fat (fig. 40). The visceral fat content is more than 7% for a fish with a condition factor of 1.4, and 6.5% for one with a condition factor of 1.2 ($r^2=0.411168$, $p<0.01$).

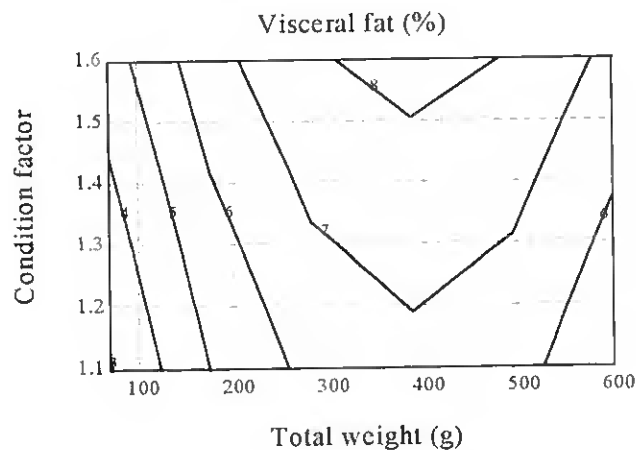


Figure 40. The relationship between total body weight (g), condition factor and percentage of visceral fat (%) in farmed seabass

It can be seen once again that the fish with high condition factor has higher content of fat (fig. 41), although fat content is not affected by condition factor as in the other species. A fish with 300 g and a condition factor of 1.4 has 18% of fat content, and a fish with 1.2 of condition factor has approximately 17.5% of fat ($r^2=0.6936661$, $p<0.01$).

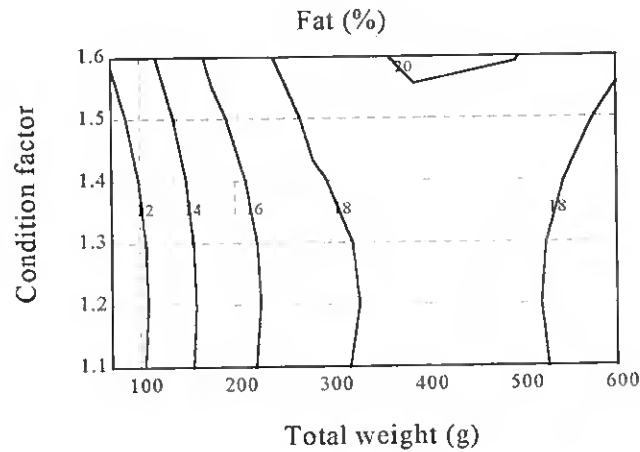


Figure 41. The relationship between total body weight (g), condition factor and percentage of fat (%) in farmed seabass

Because the fillet was not removed, neither in seabass nor in seabream, no considerations can be made about it.

4 DISCUSSION

Before starting with the discussion, one point must be made; the fact that little is known about the rearing conditions of the Japanese species, beyond the knowledge of the area where fish were collected and what feed the fish had been fed. This lack of information can affect the discussion of the results.

4.1 BODY TRAITS

Stomach content and gonad weight as two possible sources of variability in total weight, as has been reported by other authors (Ricker, 1979; Busacker et al, 1990), was not apparent in the species studied here. The results from the present work agree with those reported by Le Cren (1951), in that the weight of food in the stomach was not responsible for individual variation in weight.

In the present study no influence of gonad weight was observed in total weight, because the fish were immature, even those that had reached and surpassed maturity size. Great changes in gonad weight occur only during maturation, and that is when gonad weight can have some influence in total weight.

The disproportionate increase of gonads in size with age as has been observed in some species, was not apparent in the species studied in the present work, which shows that fish were immature. A trend toward an increase in GSI with the fish size, was reported for sole, *Solea solea* (Ramos, 1982) and red seabream, *Pagrus major* (Matsuura *et al.*, 1987; Matsuyama *et al.*, 1987), which could be related with the fact that several species are known to become more fecund as they grow larger (Love, 1980). The same trend was observed in red seabream, *Pagrus major*, ranging from 100 to 1234 g, due to the positive allometry that gonad showed against body weight, and also because fish caught during the spawning season had larger gonads than those caught during the resting season (Oikawa *et*

al., 1992). On the other hand, an isometric increase in gonad weight with fish weight was reported by Le Cren (1951) in perch, *Perca fluviatilis*, and by Eliassen and Vahl (1982a), in mature cod, *Gadus morhua*. In perch GSI was about 0.5% and did not change with size or season.

Gonad in immature fish grows, more or less, in proportion to body size. The gonadosomatic index remained fairly constant throughout the year among immature horse mackerel, *Thachurus trachurus* (Lucio and Martin, 1989), and rainbow trout, *Oncorhynchus mykiss* (*Salmo gairdneri*, Gjerde, 1989). Also for rainbow trout, Weatherley and Gill (1983a), reported that in a slow-growing group, gonad growth was isometric or even positively allometric; and in a fast-growing group negative allometric growth (not significant) shown by the gonads was due to the high variability in gonads weight of this fish group.

Concerning the influence of sex in all the studied species (except seabream), on gonad size and GSI, it is obvious that male gonad is, generally, smaller than that of the female, as has been pointed out by Love (1980). Nevertheless, a mean value of GSI of 0.39%, for both sexes, was reported for rainbow trout by Barrera and Sañudo (1987).

The effect of sex observed in seabass on other parameters, besides gonad weight and GSI, was probably due to sampling, because the distribution of the different sexes was not homogeneous. A great number of males in the lower categories and of females in the upper categories of round weight, was observed, and this could be responsible for the sex differences.

4.1.1 BIOLOGICAL MEASUREMENTS AND INDICES

4.1.1.1 Length-weight relationship and condition factor

Length-weight relationship

The allometric growth observed in all the species, follows different trends, depending on the species. Values of b greater than 3, imply that fish become more spherical as length increases, a situation that can be observed in seabream, seabass and, particularly in yellowtail, which showed the greatest value of b (table 3.3). These results are in agreement with those found for yellowtail (Garcia Gomez, 1993) and seabream (Eisawy and Wassef, 1984; Ramos, 1987; Francescon *et al.*, 1988), in other works (table 1.1).

Nevertheless, the values of b from the present work, are quite different from those reported in the above mentioned works. While yellowtail shows greater value of b than that reported by Garcia Gomez (1993), 3.66 and 3.33/3.48, respectively, seabream shows a lower value, 3.13, compared with those from the works of Eisawy and Wassef (1984) and Francescon *et al* (1988), 3.36 and 3.22, respectively. The value found in this work for seabream is very close to the one reported by Ramos (1987), 3.14.

For amberjack, the value of b (2.62) is lower than 3, which means that this species gets “thinner” as it grows. The same trend was observed in carp, *Barbus grypus* ($b=2.68$, Al-Hakim *et al.*, 1981), female common carp, *Cyprinus carpio* ($b=2.80$, Crivelli, 1981), *Oreochromis niloticus* ($b=2.75$, Al-Asgah, 1992), male and female *Hypostomus commersonii* ($b=2.80$ and $b=2.81$, respectively, Goulart and Verani, 1992), and in Mediterranean yellowtail, *Seriola dumerilii* ($b=2.66$, for a 375g fish, Garcia Gomez, 1993) (table 1.1).

On the other hand, red seabream, grows approximately to isometry, maintaining almost the same shape as it grows, due to the fact that b is very close to 3 (2.94). Species such as grey mullet, *Liza malinoptera* ($b=3.09$, Ching, 1977), female perch, *Perca fluviatilis* ($b=2.92$,

Craig, 1977), male common carp ($b=2.98$, Crivelli, 1981), luderick, *Girella tricuspidata* ($b=3.02$, Pollock, 1981), goatfish, *Mulloides flavolineatus* ($b=3.04$, Al-Absy, 1986-87), horse mackerel, *Trachurus trachurus* ($b=3.06$, Lucio and Martin, 1989), greenback mullet, *Liza subviridis* ($b=3.01$, Al-Daham and Wahab, 1991), and striped bass ($b=3.01$, Brown and Murphy, 1991), all show isometric growth (table 1.1).

In a work with juveniles of yellowtail, Safran (1992), obtained values of b approximately equal to 3, and attributed individual values differing from 3 to the particularity of the sampling (different values for b in different pairs of values). The variability in b reflected a difference in morphology among individuals and not allometric growth, as was pointed out by Safran (1992).

The explanation for the interspecific variability in b , can be attributed to bio-genetic aspects inherent to each species, and to another fact of great importance, the fact that fish were reared under different production and environmental conditions. The variability in b may reflect a difference in morphology among individuals as it was pointed out by the former researcher.

Condition factor

In the present work condition factor did not show any significant correlation with total weight. An increase in condition factor with length and age, has been observed in wild carp, *Barbus grypus* (Al-Hakim *et al.*, 1981), seabream, *Sparus aurata* (Eisawy and Wassef, 1984; Tandler and Helps, 1985), and in cultured *Oreochromis niloticus* (Quddus and Dewan, 1988; Al-Asgah, 1992). The inverse relationship between the condition factor and length found in snakehead, *Channos obscura*, by Victor and Akpocha (1992), was due to the fact that environmental conditions were not favourable for large length groups.

The use of the condition factor in biological studies is controversial, due to the fact that this index is affected by several other factors. Many studies were carry out in a way to analyse

the effect of these factors in the variation of condition factor, either under natural or artificial conditions.

The reproductive cycle in fishes involves large changes in the weight of gonads and is one of the factors responsible for the seasonal changes in the condition factor (Le Cren, 1951; Pollock, 1981; Goulart and Verani, 1982; Wilson and Pitcher, 1983; Politou and Papaconstantinou, 1991). Because the fish in the present work were immature, condition factor was not affected by the reproductive cycle.

In dab, *Limanda limanda* (Htun-Han, 1978), Arctic charr, *Salvelinus alpinus* (Jensen, 1980), rainbow trout, *Oncorhynchus mykiss* (*Salmo gairdneri*, Tveranger, 1985), and sardine, *Sardinella longiceps* (Edwards and Shaher, 1987), sex had no effect on the seasonal change of condition factor. The same was found for the species in the present study. On the other hand, the effect of sex has been demonstrated in roach, *Rutilus rutilus* (Papageorgiou, 1979), and in sole, *Solea solea* (Ramos, 1982), highest values being those of females.

In natural conditions variations in condition factor, due to the availability of food and to the feedings habits of fishes, have been reported by several researchers (Al-Absy, 1986-87; De Silva, 1980; Bagarinato and Thayaparan, 1986; Schmitt and Hubert, 1983; Edwards and Shaher, 1987; McLeese and Moon, 1989).

In studies with seabass, *Dicentrarchus labrax*, in salt marshes along the Atlantic coast of France, Mustafa *et al.* (1991) concluded that the highest value of K in October was due to the physiological preparations in autumn for the overwintering phase. This preparatory growth in immature fish was linked to anticipated temperature increment and not to gonad maturation. The low temperature in winter resulted in decrease in K, through decline in food intake, and slowing of metabolism.

Variation in condition factor, due to the availability of food, can be studied under artificial conditions, through the study of the influence of rate of feeding. This influence was studied

in Mediterranean yellowtail, *Seriola dumerlii*, by Garcia Garcia *et al.* (1993), with an increase in this index with increasing ration. This increase was also demonstrated by Cui and Wootton (1988), in minnow, *Phoxinus phoxinus*. These researchers also showed that at restricted rations, temperature had a significant effect on the condition factor, and that an increase in temperature generally causes a decrease in that index, at a given ration level.

Under artificial conditions there are other factors, than those already mentioned, that can be responsible for variation in condition factor, such as, for instance the photoperiod. Highest values of condition were obtained for larvae of seabream, *Sparus aurata*, exposed to continuous light (Tandler and Helps, 1985).

Studies comparing the performance of wild and cultured seabream, *Sparus aurata*, have been made by Eisawy and Wassef (1984), Francescon *et al.* (1988) and Sañudo *et al.* (1993). In these studies higher values of condition factor were obtained in artificially reared fish (table 1.2.).

Recently morphofunctional studies demonstrated frequent onsets of anatomical anomalies in captivity. Several factors, such as genetic factors, environmental factors (temperature, oxygen depletion, radiation), nutritional deficiencies, etc. are associated with skeletal anomalies (Francescon *et al.*, 1988; Boglione *et al.*, 1993). The condition factor is also affected by the anomalies, since abnormal fish have lower weight and length, which gives a higher index.

The condition factor may be useful by itself and in situations where a biological feature can be shown to be highly correlated directly with this index, or where other variables, affecting the condition factor, can be controlled or eliminated.

The highly significant difference between the condition factor and the relative condition factor, implied that condition was affected by length itself, because the cubic law was not obeyed, as has been pointed out by Le Cren (1951) and Gjerde (1989).

The great differences between species, in condition factor, seems to be attenuated or even to disappear when the relative condition factor is calculated. Since the species have very different shapes, and the values of relative condition factor are very similar, perhaps this indice is a useful means of comparing individuals within and between species. Because the relative condition factor "is a measure of the deviation of a given fish from the mean weight-for-length for its size group" (Weatherley and Gill, 1989).

The relative condition factor for all the species in the present work, approached one, respectively, 1.004 for yellowtail, 1.001 for amberjack, 1.001 for red seabream, 1.002 for seabream and 1.003 for seabass. These values of relative condition factor are an indication of good condition. The relative condition factor for tilapia, *Tilapia zilli*, reported by Dadzie and Wangila (1980), which also approached one, was an indication of good condition.

The higher the value of relative condition factor, above one, the better is the condition of the fish. Although, all species in the present work have similar results which differences are not significant and they are all very close to one.

Comparing the condition factors obtained for the Japanese and European species of the present study, with those from other works (table 1.2), only seabream showed a condition similar to that one reported by Sañudo *et al.* (1993), for fish with the same length. On the other hand, even although the Japanese species of the present work were larger than those in other reports, the condition factor of 1.60 for yellowtail, is lower then those reported by Tachibana *et al.* (1992) for the same species cultured in Korea and Japan. Also for red seabream, the value of condition factor of 2.27, is lower then those reported by Kora *et al.* (1990) and by Tachibana *et al.* (1992).

The use of both the relative condition factor and the length-weight relationship, as methods of directly comparing condition, is confined to comparisons between fish which are homogeneous for b in this length-weight relationship formula (Le Cren, 1951). Although the relative condition factor could be a more accurate way to calculate condition, from a practical point of view it is much more easier and rapid to determine Fulton's condition

factor. From weight and length data, an aquaculturist can easily determine the condition factors of his fish. For this reason Fulton's condition factor was used in further studies in this work, instead of relative condition factor, not only as the value itself, but also as a tool to predict other important information for the aquaculturist.

4.1.1.2 Percentage of dressed weight and total weight

The values of percentage of dressed weight, obtained in the present work in all species, except seabass, are relatively higher than those reported for rainbow trout by several other researchers. Seabass had a percentage of dressed weight in average of 87.5%, and the other studied species a value higher than 91%. Nevertheless, these values are influenced by the weight of viscera. Among all the studied species, seabass is the one with the greatest proportion of viscera, due to the great amount of fat deposited in the abdominal cavity, and consequently the one with the lowest percentage of dressed weight.

However, different values of percentage of dressing weight have been reported for rainbow trout, mainly due to the different methodology employed in the determination of dressed weight. Values of approximately 77% to 80% (without kidneys and skin) in fish with a size range from 50 to 250g, were found by Weatherley and Gill (1983a); a value of 87.7% (without heart, kidney and swim-bladder) in fish with a mean weight of 226g, was found by Barrera and Sañudo (1987); and values from 86.1% to 88.0% (without kidneys) in fish over 3 kg, were found by Gjerde (1989).

The different methodology is not the only factor responsible for the different values reported. The dressing percentage is greatly influenced by date of slaughter, due to the variation in the amount of abdominal fat and gonad weight in the case of sexually mature fish. Gonad had no influence in the present work because all fish were immature. Gjerde (1989) quotes other authors, who have observed mean values that ranged from 77.4% to 93.8%, in rainbow trout, depending on the time of the year that fish was slaughtered.

Also feeding frequency had a significant effect on the percentage of dressed weight in channel catfish, *Ictalurus punctatus*, the value (without head) being higher in fish fed twice daily (63.2%) compared with fish fed once daily (59.5%) (Webster *et al.*, 1992b).

Huxley's allometric formulae, $Y=aX^b$, was used by Weatherley and Gill (1983a) as a technique for analysis of relative growth of body components in immature rainbow trout, *Oncorhynchus mykiss* (*Salmo gairdneri*), growing at different rates. The positive allometry of carcass against body weight, reported by Weatherley and Gill (1983a), was not observed in the present study for any of the species. On the contrary, an increase in body weight induced a decrease in the proportion of carcass, probably due to reciprocal changes in other tissues, as Weatherley and Gill (1989) pointed out, when they reported that carcass weights tend to be greater in food-deprived fish (78% Vs 82%). This means that lighter fish has a greater proportion of carcass. The weight gain in Arctic charr, *Salvelinus alpinus*, during a restricted feeding for 8 weeks, resulted from an increase in eviscerated carcass tissue. Some growth of carcass tissue was maintained by the depletion of both visceral and liver reserves, resulting in the decrease of the weight of these organs (Miglav and Jobling, 1989).

Although the percentage of dressed weight decreased, an increase in the proportion of fillet was observed only in yellowtail, which means that there was an increase in muscle with body weight. A percentage of fillet on whole body represented 58.7% for yellowtail, 60.8% for amberjack and 57.3% for red seabream, in the present work. Rainbow trout shows values of percentage of fillet of 58.67% (Barrera and Sañudo, 1987), channel catfish shows values of 55.0% (Webster *et al.*, 1992a), and more than 60% of salmon is fillet (Åsgård *et al.*, 1995).

4.1.1.3 Viscerosomatic index (VSI) and total weight

The decrease in the percentage of dressed weight with total weight, was accompanied by an increase in the proportion of the viscera. This means that there is an inverse relationship between the proportion of carcass and the viscerosomatic index, which is in agreement with

Weatherley and Gill (1989). The decrease in the proportion of carcass with body weight, is probably due to reciprocal changes in other tissues.

This can be seen when comparing species, i.e., the species with the highest percentage of dressed weight is the one with the lowest proportion of viscera (table 3.1). Amberjack has a percentage of dressed weight of 94.2% and a VSI of 5.2%, on the other hand, seabass has 87.5% and 10.9% of dressed weight and VSI, respectively.

For amberjack and red seabream, VSI did not change significantly with body size. The same result was found for rainbow trout, *Oncorhynchus mykiss* by Kim and Kaushik (1992).

For rainbow trout, Gjerde (1989) reported values of VSI ranging from 9.7% to 11.9%, in fish studied in 3 different years, and weighing more than 3 kg, while Kim and Kaushik (1992), reported values ranging from 8.4% to 9.6%, in fish heavier than 100gr.

In the present work the value of VSI found for seabass, 10.9%, was higher than those reported by Tibaldi *et al.* (1991), in which values of VSI ranged from 9.12% to 9.79%, and similar to the ones reported for rainbow trout by Gjerde (1989). For red seabream, a VSI of 7.87% is slightly lower than the one reported by Kora *et al.* (1990) (8.2%), for the same species but in fish with a mean length of 28.2 cm, i.e., a smaller fish.

Since total viscera includes the weight of all visceral organs, one or more of these organs is responsible for the increase in its proportion of body weight.

4.1.1.4 Percentage of gut, liver and visceral fat and total weight

Red seabream, seabream and seabass showed a decrease in the proportion of gut (stomach+intestine), with increasing body weight.

A proportional decrease in the digestive system (including the mesenteric fat) with increasing body weight (ranging from 13.2% to 16.3%) was observed in rainbow trout, *Oncorhynchus mykiss*, (*Salmo gairdneri*), by Denton and Yousef (1976). The same trend was reported by Weatherley and Gill (1983a), also for rainbow trout, and by Oikawa *et al.* (1992) for red seabream, *Pagrus major*, although for both species the mesenteric fat was not included in the digestive system.

As was the case for amberjack studied in the present work, Barrera and Sañudo (1987), could find no significant relationship between the weight of gut and body weight, in rainbow trout.

The increase in the proportion of gut verified in yellowtail, probably resulted from a certain increase in the mesenteric fat, rather than the gut itself. In yellowtail and amberjack “gut” included the mesenteric fat, because it was impossible to dissect away this tissue due to the fact that it was surrounding the pyloric caecae. Probably the proportion of gut also decreases with body weight in these two species.

A percentage of gut of 7% and of 5.35% (higher in females although not significantly so), were found in rainbow trout, of approximately the same size, by Weatherley and Gill (1983a) and Barrera and Sañudo (1987), respectively. The present study showed values of percentage of gut (table 3.1), much lower than those reported for rainbow trout. Even yellowtail and amberjack, which have the same gut morphology as rainbow trout, presented values of 4.07% and 3.89%, respectively.

The trend toward an increase in HSI with increasing body weight in yellowtail and seabream, was also reported for juvenile striped bass and hybrid striped bass by Brown and Murphy (1991), when they found a high positive correlation between liver weight and body weight.

Huxley's allometric formula, $Y=aX^b$, was employed in the study of relative growth of organs in red seabream, *Pagrus major*, by Oikawa *et al.* (1992), obtaining different results,

depending on the size of the fish. For these researchers the hepatopancreas showed isometry in smaller fish (0.0033 to 95g), and positive allometry in bigger fish (330 to 1234g). This trend in the bigger fish, could be related with the relative importance of liver in the maturation process, because this group included fish that had probably reached maturity. Love (1980) points out that as fish grow older they acquire a progressively greater mass of lipid in the muscle or liver, presumably to supply gonads which, in some species, increase in size with age disproportionately to the body size of the fish.

In mature fish of some species, energy reserves for gonadal maturation, come from the liver and muscle, resulting in the decline of the HSI, which reaches the lowest value after spawning (Htun-Han, 1978; Medford and Mackay, 1978; Dawson and Grimm, 1980; Adams and McLean, 1985; Tveranger, 1985; Crupkin *et al.*, 1988; Lenhardt, 1992; Neumann and Murphy, 1992). In the present study, red seabream was the only species to present a decrease in HSI with body weight, which could be related with the fact that some of the individuals had already reached and surpassed the maturity size. But because fish in the present work were immature, the effect of reproductive cycle on liver weight was not observed.

Also Weatherley and Gill (1983a), working with immature rainbow trout, found that in post-fingerlings, liver showed a negative allometry, increasing less rapidly than body weight. Using the allometric parameters, the relative size of organs (HSI) was calculated. The results showed that, regardless of trout growth rates, HSI decreased with increasing body weight, and it is remarkably constant with respect to total body weights.

On the other hand, an increase in liver weight with increasing body size in goldfish, *Carassius auratus*, was observed by Delahunty and Vlaming (1980), although this relationship changed seasonally, with the lowest weight after the spawning season. When the HSI was related to body weight minus gonad weight, there were no significative changes over the range of body weight, thus suggesting that HSI is an appropriate expression of liver size.

Amberjack and seabass did not show any significant change of liver weight relative to body weight. Also, Denton and Yousef (1976), measuring the organs weight during the first 14 months of life in rainbow trout, *Oncorhynchus mykiss* (*Salmo gairdneri*), found that the liver did not change significantly during the study and weighed between 1.4% and 1.9% of body weight.

The hepatosomatic index gives a more accurate description of growth in immature fish than in older and mature fish, due in part to additional reproductive energy demands placed on the liver.

The mean value of HSI for seabass, 2.14%, falls within the range reported by Mustafa *et al.*, (1991) (varying approximately from 1.5% to 3%) for the same species, during overwintering. In seabream, the value of HSI, although a little higher, 1.92%, is very close to the one found in intensively cultured seabream (1.73%), by Sañudo *et al.* (1993).

In most of the cases, differences in HSI between populations of the same species reflect the fact that the hepatosomatic index can be affected by several factors. Generally it is possible to observe an increase in this index with the increase in energy ingested (Tibaldi *et al.*, 1991; Kim and Kaushik, 1992; Nematipour *et al.*, 1992); with increasing growth rate (Corraze *et al.*, 1993); and with increasing ration level (Hidalgo *et al.*, 1987; Cui and Wootton, 1988; Miglavs and Jobling, 1989). Feeding frequency did not influence the hepatosomatic index of *Epinephelus akaara* (Kayano *et al.*, 1993) or of *Oncorhynchus mykiss* (Zoccarato *et al.*, 1994a). The influence of temperature was shown by Adams and McLean (1985), in *Micropterus salmoides*, and by Cui and Wootton (1988) in minnow, *Phoxinus phoxinus*, HSI increasing with increasing temperature.

Comparing wild and cultured seabream, *Sparus aurata*, Sañudo *et al.* (1993) found higher values of hepatosomatic index in the cultured fish, although with the highest values in fish cultured extensively (1.73 for cultured, 1.28 for wild and 3.10 for extensively cultured fish).

Only the European species showed a significant correlation between the amount of visceral fat and body weight, with an increase in visceral fat with increasing the fish size. The same trend was reported in immature rainbow trout by Weatherley and Gill (1983a), who found that the relative growth of visceral fat had a positive allometry. An increase in visceral lipids stores with body weight was also observed in goldfish, *Carassius auratus* by Delahunty and Vlaming (1980).

The Japanese species, red seabream, did not show any significant change in the amount of visceral fat with increasing body weight. Also in red seabream, *Pagrus major*, Oikawa *et al.* (1991) reported negative allometry in this parameter, although this result was not statistically significant.

In brown trout, *Salmo trutta*, and Arctic charr, *Salvelinus alpinus*, some energy reserves are stored as fat in musculature, but mostly as fat in the abdominal cavity within the gut wall and pyloric caecae. Thus, Jensen (1980), used the “Gut-index” (dry matter of gut / gut wet weight), to measure the gross nutritional state in these two species. No relationship was found between this index and body weight, but it increased with increasing storage of fat in the gut, which seems to be the main organ for energy storage in Arctic charr and brown trout.

The increase in visceral fat is not only related with increasing body weight, but also with the nutritional factors that can affect the amount of fat deposited in the abdominal cavity. Consequentely, as pointed out by Gjerde (1989), a high content of abdominal fat will cause a high viscerosomatic index. The factors that affect HSI, have the same effect on the fat depot, and consequently on VSI.

Low rations leads not only to slower growth but to less stored fat (Weatherley and Gill, 1989). In juveniles of seabass, *Dicentrarchus labrax*, Hidalgo *et al.* (1987) found that VSI decreased with a decrease in ration size and increase with temperature (range from 3.9% to 6.85%).

Higher intraperitoneal fat ratios have been reported for fish fed diets with high energy or lipid levels (hybrid striped bass: from 3.40% to 6.43%, Nematipour *et al.*, 1992; channel catfish: from 2.10% to 3.84%, Stowell and Gatlin III, 1992). For Arzel *et al.* (1994), high lipid diets did not induce an increase in visceral fat deposition in *Salmo trutta*. The VSI (except liver) ranged from 7.4% to 8.3%, but the values were not significantly different. Tibaldi *et al.* (1991), in seabass, *Dicentrarchus labrax*, also failed to observe any influence of energy level on the VSI, with values ranging from 9.12% to 9.79%.

Feeding frequency (Kayano *et al.*, 1993; Zoccarato *et al.*, 1994a), level of protein at different feeding frequencies (Webster *et al.*, 1992a) and different ratios of digestible protein:digestible energy, through the incorporation of different carbohydrates (Kim and Kaushik, 1992), have no effect on VSI or in the amount of fat deposited in the abdominal cavity.

Seasonal changes in VSI due to overwintering, gonad maturation and food availability, have been reported by Adams and McLean (1985) in *Micropterus salmoides*, and by Neumann and Murphy (1992), in white crappie, *Pomoxis annularis*. The former researchers reported that VSI was lowest in the warmer periods, increasing during the fall and decreasing over the winter when feeding was minimal.

The transfer of lipids from one organ to another, was observed by Adams and McLean (1985), in largemouth bass, *Micropterus salmoides*. In order to maintain the high values of hepatosomatic index, the liver sequestered energy stored in viscera, which led to decreasing values of viscerosomatic index.

The amount of visceral fat obtained for seabass, 6.24% (table 3.1), is similar to the amount reported by Nematipour *et al.* (1992), 6.43% for hybrid striped bass fed with high energy diets.

The lack of definite patterns of growth for the different organs and tissues in amberjack and red seabream, was probably due to the small size of the sample of amberjack and to the heterogeneous distribution of sizes in red seabream.

From the above and table 3.1, the increase of VSI in seabass is mainly due to the increase in visceral fat, which represents the main tissue in the viscera, and consequently will cause a high viscerosomatic index. As a consequence, this species has the lowest dressing percentage. The same trend can be observed in red seabream but only analysing table 3.1, due to the greater proportion of visceral fat compared with the other visceral organs.

The increase in VSI, in seabream and yellowtail, is due to the increase in HSI and visceral fat, although for yellowtail this supposition is based on the growth verified in the percentage of gut, since this organ decreased in the other species, as well as in the studies reported by Denton and Yousef (1976), Weatherley and Gill (1983a) and Oikawa *et al.* (1992). No observations can be made for amberjack. Since fish were immature gonad growth had no influence on the increase of VSI.

4.1.2 CHEMICAL COMPOSITION

The chemical composition of the species studied in this work, showed a high fat content in all species, particularly in red seabream, seabream and seabass. Analysing table 3.1, it appears that the major differences among species are in moisture and fat content.

The body composition of ten marine migrants and one freshwater fish species caught in estuaries on South Africa, were studied by Marais (1990). The major differences found between species were also in fat and moisture content. Values of 16.1% and 1.3% of fat and 61.1% and 75.5% of moisture, were found in *Valamugil cunnensius* and *Argyrosomus hololepidotus*, respectively. On the other hand, Ahmed *et al.* (1984), studied the biochemical composition of seven species of gobi fish, and observed that the greatest

variation between species was recorded in the moisture content, followed by protein content.

The values found in this work, fall outside the general ranges presented by Brown and Murphy (1991). A explanation for this situation could be: (a) that round fish was analysed, inclusive of head, skin and bones; (b) because these are fatty fish, with high content of fat and low content of moisture; or (c) some loss of water may have occurred during the freezing process.

Some variation in body composition data can be attributed to differences in the analytical methods. Tissue for proximate analysis should, if possible, be removed from freshly killed animals and, if necessary, preserved for later analysis. The preservation of fish for further analyses can present some problems, mainly concerning the loss of water. Gruda and Postosky (1986), reported losses of 5% in fresh fish, and 8% in fish after spawning. Moreover, this percentage depends on the shape of the fish (ratio surface/volume), size of the fish (smaller fish lose more water), and on body composition, because the losses in leaner fish are greater than in fatty fish.

Other authors have also reported values of chemical composition that fall outside the present ranges. As pointed out by Brown and Murphy (1991), the range of values for chemical composition are correct mainly for salmonids, in other species the values may be outside these ranges.

An example that is in agreement with what has been reported by other researchers are the values of crude composition obtained for yellowtail, *Seriola quinqueradiata*, by Date and Yamamoto (1988). The crude composition of muscle of yellowtail, *Seriola quinqueradiata*, with a size range of 1.2 to 4.4 kg, reported by these researchers were 55.3% of moisture, 23.6% of protein, 14.0% of lipids and 1.8% of ash. The same researchers also presented the values of crude composition for this species that are included in the standard table of food composition in Japan, which are 61.1% of moisture, 21.2% of protein, 16.1% of crude lipids and 1.3% of ash. Comparatively, the values of chemical composition obtained

for yellowtail in the present work shows higher content of moisture (67.5%), lower content of protein (19.6%) and fat (10.4%), and higher content of ash (3.2%).

Intra and interspecific differences in body composition are reported by several authors. Analysis of whole body lipid composition performed on 3 strains of rainbow trout, *Oncorhynchus mykiss* (*Salmo gairdneri*), showed higher body fat content in the slow growing strain of this species (Corraze *et al.*, 1993). For the same species, Gjerde (1989), in fish weighing 2 to 4 kg, found values for fat content in the meat ranging from 13.9% to 15.8%, while Tveranger (1985), reported values of 10% to 12% of fat, for fish weighing on average 1.4 kg.

As pointed out by Gjerde (1989), fat content in meat of rainbow trout, *Oncorhynchus mykiss* (*Salmo gairdneri*), appears to vary a lot between and within groups of fish, while the protein content appears to be quite stable, although some variations can be expected for this component also.

The comparison between two races of carp, yamato and mirror carp, *Cyprinus carpio*, showed that they were significantly different, concerning fat (4.5% and 3.7%, respectively) and ash content (2.7% and 3.0%, respectively) (Shimma, 1986). But when Shimma and Maeda (1986), crossed the two races and compared the hybrid (Yamato-Mirror) with yamato race, significant differences were reported in the content of fat (4.8% Vs 5.9%) and moisture (77.1% Vs 75.9%), with low values of fat and high content of moisture in the hybrid.

Proximate composition of the muscle of fish can vary with the part of the muscle that is being analysed. The muscle of cultured yellowtail, *Seriola quinqueradiata*, was divided into four parts: dorsal, ventral, caudal and dark muscle, and each part analysed separately for crude composition, by Date and Yamamoto (1988). Higher moisture content and crude protein was reported in the caudal muscle, and higher crude lipids and ash in the dark muscle. Ahmed *et al.* (1984), analysed the dorsal muscle, ventral part and tail portion of seven species of gobi fish, and obtained a higher moisture content and low protein content

in the tail portion; the fat content was highest in the ventral portion and the protein content was the highest in the dorsal region; ash content did not vary significantly.

The differences in body composition among populations of the same species are not only due to biological phenomena, such as genetic or behavioural variability among individual animals, but also due to the different practices during production.

Body composition can vary in fish reared under different production systems. Individual components do not differ significantly from each other in fry reared under different conditions, or those from nature, or between species of mugilids (De Silva, 1980), although in seabream, *Sparus aurata*, a significant difference was found in percentage of fat (20.61% Vs 8.80% on dry weight), between cultured and wild fish, with approximately the same weight (335-338 g). For this species the moisture content ranged from 70.70% to 74.75%, and the protein content from 21.41% to 21.08%, in cultured and wild fish, respectively (Sañudo *et al.*, 1993). The values found, in the present work, for seabream with the same size ranges, shows a lower content of moisture and protein and a higher content of fat, which means that this species is fatter than the cultured ones reported by former researchers. The present species had values of 63.6% of moisture, 17.9% of protein and 14.5% of fat in the whole fish.

Values of 2.6% and 3.4% of fat content in visceral part and muscle, respectively, in cultured (mean body weight 679 g) red seabream, *Pagrus major*, were reported by Kora *et al.* (1990). The values reported for wild red seabream by the same authors, corresponded to 28.3% and 56.2% of the values found in cultured fish, respectively. Tsuchimoto *et al.* (1992) obtained for the same cultured species, with a mean range of body weight of 39-897g, values of 1.18 % of fat and 79.2% of water in the white muscle. Red seabream analysed in the present work, showed higher values of fat content either in the muscle (12.2% of fat in the fillet) or in the whole fish (16.4%), although this sample had a mean body weight of 1506.7g.

The level of fat content achieved by a fish toward the end of the feeding period is therefore the result of the feeding conditions and adequately reflects the food supply during the period (Jensen, 1980). Lower levels of body fat content in yellowtail, *Seriola quinqueradiata*, and red seabream, *Pagrus major*, cultured in Korea, when compared with those cultured in Japan, were reported by Tachibana *et al.* (1992). The authors suggested that this differences were caused by a smaller food intake, by the former. Fish from Japan were heavier and longer, which could have some effect on the results, although this fact was not mentioned in the work.

Fish experiencing low energy intake have to use energy stored in body tissues as lipid and protein, much of which is mobilised from the muscle tissue (Love, 1980). After a time, the concentration of lipid, protein and energy will decrease and their volume will be replaced by water (Busacker *et al.*, 1990).

Increased amounts of dietary lipids are known to have a sparing effect on dietary protein. Many researchers accomplish studies in different species, in order to determine the optimum level of energy, or the incorporation of different sources of lipids and protein, or the ratio energy to protein, etc. Generally the results from these studies agree that increased amounts of dietary lipids result in fish with increased amounts of whole body fat and reduced amounts of whole body protein and moisture (Reinitz and Hitzel, 1980; Cowey, 1993; Nematipour *et al.*, 1992; Stowell and Gatlin III, 1992; Kentouri *et al.*, 1993; Arzel *et al.*, 1994).

In part, the progress in fish farming is due to progress in feed technology, with a decrease in protein content and an increase in fat content, in the commercial diets. As a consequence of this progress higher fat levels have been found in fish body (Åsgård *et al.*, 1995). The supply of a high-quality diet to stimulate growth and thus reduce rearing time in aquaculture production implies an increase in fat content (Fauconneau *et al.*, 1995).

The results from several studies agree that dry matter content, lipid content and energy content increase with ration. However, protein and ash content showed somewhat different

trends with ration in different studies and usually have a less obvious response (Brett *et al.*, 1969; Weatherley and Gill, 1983b; Hidalgo *et al.*, 1987; Cui and Wootton, 1988; Miglavs and Jobling, 1989; Cowey, 1993; Zoccarato *et al.*, 1993, 1994b).

When fish undergo a starvation period or restricted feeding, a decrease in lipid content and an increase in moisture content occurs, indicating that lipids are the primary source of energy (Parker and Vanstone, 1966; Suppes *et al.*, 1967; Denton and Yousef, 1976; Ahmed *et al.*, 1984; Galicka, 1984; McLeese and Moon, 1989; Miglavs and Jobling, 1989), although the main lipid storage organs vary among species. In some cases, longer periods of food deprivation may result in protein utilisation and further increases in muscle water content (Parker and Vanstone, 1966; Suppes *et al.*, 1967; McLeese and Moon, 1989).

Denton and Yousef (1976), found an increase in ash content of the total body during the starvation period, probably due to an increase in the proportion of skin, scales and bones relative to muscle tissue. Brown and Murphy (1991) point out that protein and ash are not as dynamic as fat.

Body composition is affected irregularly by feeding frequency (Grayton and Beamish, 1977; Webster *et al.*, 1992a, b; Kayano *et al.*, 1993; Zoccarato *et al.*, 1994a) and temperature (Brett *et al.*, 1969; Weatherley and Gill, 1983b; Gill and Weatherley, 1984; Hidalgo *et al.*, 1987; Cui and Wootton, 1988).

In sexually mature fish, energy is used not only to support metabolism but also to supply the energetic demands of reproduction. Dawson and Grimm (1980), reported that in plaice lipid supplies 75% of the energy for metabolism and so forms the major reserve; and that 42% of the energy assimilated during the year is devoted to reproduction. There is a considerable drain on energy reserves due to sexual maturation and it is on females where this drain is heaviest (Craig, 1977).

Although body traits can be affected by several factors, if fish are reared always under the same conditions, it is possible to establish patterns of growth and standard values that will be useful for the aquaculturist.

4.1.2.1 Moisture content and total weight

The effect of size on body composition, particularly on moisture content showed to have a very definite effect. The low percentage of moisture with increasing size, that was reported for many marine and freshwater species (Groves, 1970; Denton and Yousef, 1976; Ahmed et al, 1984; Galicka, 1984; Gill and Weatherley, 1984; Weatherley and Gill, 1983b, 1989; Date and Yamamoto, 1988), can also be observed in the present study, in almost all the species.

4.1.2.2 Fat content and total weight

The increase in fat content with increasing body size, is also in agreement with the results reported by many other researchers (Groves, 1970; Denton and Yousef, 1976; Ahmed et al, 1984; Galicka, 1984; Gill and Weatherley, 1984; Weatherley and Gill, 1983b, 1989; Date and Yamamoto, 1988).

4.1.2.3 Moisture content and fat content

The opposite patterns of growth of moisture and fat, shows the inverse correlation between these two constituents, which mean that one constituent is replaced by the other. This relationship was reported in yellowtail by Date and Yamamoto (1988), and seabream by Marais and Kissil (1979).

Many other researchers, working with different species, reported this widely known negative correlation between moisture and fat content or the positive correlation between dry matter and fat content (Galicka, 1984; Tveranger, 1985; Miglavs and Jobling, 1989; Weatherley and Gill, 1989; Marais, 1990; Marais and Venter, 1991; Al-Asgah, 1992).

4.1.2.4 Protein content and total weight

While patterns of growth for moisture and fat are common to all species, protein and ash content shows different patterns depending on species.

A decrease in the proportion of protein with increasing size observed in yellowtail, was also found for the same species by Date and Yamamoto (1988), in juvenile striped bass and hybrid striped bass by Brown and Murphy (1991) and in tilapia *Oreochromis niloticus* by Al-Asgah (1992).

In an allometric study on rainbow trout, *Oncorhynchus mykiss* (*Salmo gairdneri*), Weatherley and Gill (1983b), showed a negative allometry of protein against body weight. These researchers compared the results of this study with those of the early study of relative growth of tissues, in the same experimental groups (Weatherley and Gill, 1983a). Therefore because of the magnitudes of their allometry constant, carcass increases with body weight, while liver, gut, skin, decrease. Since, carcass comprises at least 75% of body weight, it is likely that much of the estimated decrease of protein, results from decrease in muscle protein content, and since lipid content increases over the weight range, this increase must be attributable to general increases of lipid content of all major tissues.

A relatively constant (15.3%) level of protein and an increasing ash content with body weight (2.4% to 2.7 %), in rainbow trout, *Oncorhynchus mykiss* (*Salmo gairdneri*) was assumed by Galicka (1984).

On the other hand, the trend toward the increase in protein content with size observed in the fillet of red seabream, was also reported in the study of seven species of gobi fish (Ahmed *et al.*, 1984), in seacatfish, *Galeichthys feliceps* (Marais and Venter, 1991), and in rainbow trout, *Oncorhynchus mykiss* (*Salmo gairdneri*, Denton and Yousef, 1976). On bluntnose minnow, *Pimephales notatus*, Gill and Weatherley (1984), verified an increasing tendency in protein content with increasing body wet weight, and a decrease with increasing body dry weight (except at 15°C).

In rainbow trout, *Oncorhynchus mykiss* (*Salmo gairdneri*), Tveranger (1985) reported that with increasing fat content, the protein content (% of dry matter) is reduced with a simultaneous increase in dry matter content. This indicates that fish contain an approximately constant quantity of proteins in the muscle, and variation in fat content create the main changes in dry matter content. This is natural since the fat reserves are much more mobile than the proteins, are mainly used as an energy source, while the protein are used for growth and tissue formation. As pointed out by Brown and Murphy (1991), fatty fish exhibit an inverse linear crude fat-water relationship and a positive linear crude protein-water relationship, while nonfatty fish show an inverse relationship between protein and water. In yellowtail, protein and moisture follow the same trend with body weight.

Fillet comprises more than half of the body weight, so that variations in protein content result from variations in muscle protein content (Weatherley and Gill, 1983b). Since in yellowtail fillet comprises at least 59% (table 3.1) of body weight, it is likely that much of the estimated decrease in protein, results from decrease in muscle protein content, and since lipid content increases, this increase must be attributable to general increases of lipid content of all major tissues.

On the other hand, in red seabream, an increase in protein content in the fillet, results from increase in muscle protein content, but nothing can be said about lipids or moisture content, due to lack of significant results.

Although not significant, amberjack showed more or less the same trends as yellowtail, while for seabream and seabass, there is a trend toward a slight increase in protein content with body weight.

4.1.2.5 Ash content and total weight

The different patterns of growth of ash, depending on species, reported by other authors, were not observed in this study. In the present work all species showed the same trend, a decrease in ash content with increasing total weight.

The same trend was reported for yellowtail, *Seriola quinqueradiata*, by Date and Yamamoto (1988) and for juvenile striped bass and hybrid striped bass by Brown and Murphy (1991). A general decrease in the accumulation of minerals with fish size, was reported by Weatherley and Gill (1989, quoting Shearer, 1984). This trend could be related to the negative allometry in body tissues (other than carcass) in post-juveniles. A negative allometry in head, fins, and scales of the trunk was also observed by Oikawa *et al.* (1992), in red seabream, *Pagrus major*. For red seabream in the present work, body ash remained relatively constant with a trend toward a decrease, although this trend was not statistically significant.

On the other hand, in rainbow trout body ash content remained relatively constant during the first year of life, indicating that the relative proportions of skin, scales and bones remain constant with growth during this period of life (Denton and Yousef, 1976). A constant amount of ash content, was also observed in the study of seven species of gobi fish (Ahmed *et al.*, 1984).

Seacatfish, *Galeichthys feliceps* (Marais and Venter, 1991), tilapia, *Oreochromis niloticus* (Al-Asgah, 1992), and rainbow trout, *Oncorhynchus mykiss* (*Salmo gairdneri*, Galicka, 1984), show an increase in ash content with body size.

The variation of the different body constituents with size, probably define and separate the species by tissues where fish mainly stores fat. If protein content decreases it may be because the fish in question store fat mainly in the muscle, but if it increases or remains relatively constant, it is because fish preferentially stores fat in other tissue rather than muscle. Nevertheless, the relative importance of different sites and tissues in lipid storage depends on whether or not fish have been fed intensively on artificial diets.

4.1.3 REGRESSION EQUATIONS

For the fish populations investigated in the present study and reared under these particular conditions, body traits with interest to the aquaculturist, such as, percentage of dressed weight, percentage of fillet, VSI, percentage of visceral fat and body composition, can be determined, with a certain accuracy, applying regression equations. The different regression equations show the correlation that exists between the body traits and body weight or moisture content, in the case of fat.

The widely known negative correlation between fat and moisture content, can be observed in the highly significant regression equation between these two components, either in the Japanese or European species. From the equations in table 3.4, it is easy to observe that with decreasing water content, the fat content increases, and vice-versa.

Regression equations describing the relationship between percent fat and percent water for body organs of goldeye, *Hiodon alosoides*, were calculated by Craig *et al.* (1989). Significant equations were obtained for liver, ovaries, testes and carcass; for muscle and gut the equations were not significant. All these equations showed the inverse relationship between fat content and moisture content.

Comparing the regression equations from the present work for yellowtail and red seabream, with those reported for the same species by other researchers (table 1.3), the values obtained for fat content by applying these equations were very similar for red seabream, but higher for yellowtail. For instance, for a fish with a moisture content of 70%, red seabream from this study had a fat content of 7.73%, while in the work of Tsuchimoto *et al.* (1992), the value is 7.37%; yellowtail had 7.80% of fat content in this study, while Date and Yamamoto (1988) obtained values of 2.22% of fat.

It is obvious that these equations are dependent on the rearing conditions and are specific of each particular case, and they can only be used to give a good approximation, in a way to allow the aquaculturist to control how fish is growing and optimise its utilisation.

Moisture content (or dry matter) can also be used to predict the amount of other body constituents, such as, protein and ash. The relationship between protein or ash content with moisture content, shows different trends, which is in agreement with the reported different patterns of growth, in some species, of these elements with increasing size. Although this relationships was not studied in the present work, it was possible to see that in yellowtail, protein and ash follow the same pattern of growth as moisture, which means that these two parameters probably have a positive relationship with moisture. The same relationship could be observed in amberjack, seabream and seabass, concerning ash content. No comments can be made in relation to red seabream because there was not a significative pattern of growth for moisture, although protein showed a positive relationship with body weight.

Because sometimes water content is not possible to determine, and also because the determination is time-consuming and requires the death of the fish, there are other parameters that are easy and rapid to determine, and may be used to predict body composition or an organ weight, as for instance, body wet weight.

In an allometric study of protein, lipid and energy content, of fish growing at different growth rates, Weatherley and Gill (1983b) and Gill and Weatherley (1984) are in agreement that for the various experimental groups the majority of body components can be accurately estimated from body (wet or dry) weight, with high coefficient of determination (r^2). Despite the differences among treatments, equations for the pooled data indicate that acceptable estimates of the relative magnitude of body components of rainbow trout, *Oncorhynchus mykiss* (*Salmo gairdneri*), and bluntnose minnow, *Pimaphales notatus*, can be obtained regardless of growth history - if all that is required is a good approximation.

The same can be said for the Japanese and European species studied in the present work, due to the accurate estimation of the different body traits from body wet weight.

Besides the use of body weight, other parameters have been used by many other researchers to predict accurately body composition, such as, length and indices of condition. The equations representing these relationships are presented in table 1.4.. Nevertheless, the close relationship between an organ index and the energy content in that organ or in the whole body, depends on which tissues are used as stores of primary energy reserves.

4.2 AQUACULTURE ASPECTS

As has been mentioned before, it has been reported that size and age (Al-Hakim *et al*, 1981; Eisawy and Wassef, 1984; Tandler and Helps, 1985; Quddus and Dewar, 1988; Al-Asgah, 1992; Victor and Akpocha, 1992), the reproduction cycle (Le Cren, 1951; Pollock, 1981; Wilson and Pitcher, 1983; Politou and Papaconstantinou, 1991; Goulart and Verani, 1992), and food availability (De Silva, 1980; Schmitt and Hubert, 1983; Bagarinato and Thayaparan, 1986; Al-Absy, 1986-87; Edwards and Sharer, 1987; McLeese and Moon, 1989; Mustafa *et al*, 1991), have definite effects on the condition factor. Ration level is one of the most important factors responsible for variations in the condition factor (Cui and Wootton, 1988; Garcia Garcia *et al*, 1993).

Weatherley and Gill (1983b), demonstrated that for rainbow trout, *Oncorhynchus mykiss* (*Salmo gairdneri*), fairly good correlation are obtainable for lipid (% wet weight), and body dry weight versus condition factor, such that reasonable estimates of these variables could be obtained from a knowledge of fork length and body wet (live) weight. Also Cui and Wootton (1988), obtained similar results with significant correlation between condition factor and body composition (% dry matter), with protein and ash showing a significantly negative correlation with condition factor, and lipid and energy content showing a positive correlation with this index.

Because the condition factor is an index that relates weight and length, variations in condition rapidly translate changes in the rearing conditions and consequently in the

production level. In aquaculture, variations in the condition factor, induced for instance, either by the quantity or quality of the feed, are an indication of the changes that occur in the fish body, and are induced by factors controlled by the aquaculturist. These changes in organs and tissues are a function of the different patterns of growth of the species. Nevertheless, the changes are related to the nutritional history of the fish (Groves, 1970).

Different values of K in fish with the same weight, is the result of changes in the body traits of the fish. The fish who present the higher value of K is the one that is in better condition, because body traits were allowed to grow as much as it was possible, concerning the particular rearing conditions.

Percentage of dressed weight, VSI, percentage of fillet, percentage of visceral fat and percentage of fat, are parameters that represent the level of production, and that may be translated into economic models by the aquaculturist.

Relating these parameters with condition factor, it is possible to know how they behave when changes in the rearing conditions occur, and at the same time determine which is most affected by that change. This relationship can be observed in the 3D scatter plot, but on the other hand, the characteristics of sampling define the type of the graphics and its interpretation (the way that the variables are related).

In all the species from the present work, the inverse relationship between the percentage of dressed weight and VSI is common, i.e., an increase in the condition factor leads to a reduction in the percentage of dressed weight and to a consequent increase in the proportion of viscera. The importance of this relationship will depend on the species to be cultured and how the final product will be processed.

If two fishes have the same weight, although with different values of condition, this means that the fish with the higher condition factor is more round and smaller than the one with the lower condition. If the proportion of carcass is lower in the smaller fish (higher

condition factor), then it is because the proportion of viscera in this fish is high, compared with the larger fish with the same weight.

Carcass weights tend to be greater in food-deprived fish, probably due to reciprocal changes in other tissues, as it was referred by Weatherley and Gill (1989). In Arctic charr the growth of carcass was maintained by the depletion of both visceral and liver reserves, resulting in the decrease of the weight of these organs (Miglav and Jobling, 1989). And probably, although not mentioned, to a decrease in VSI. This is in agreement with the inverse trend showed by the percentage of dressed weight and VSI, in the Japanese and European species, with the increase in condition factor. A fish with a higher condition factor, has a relatively lower percentage of carcass and a higher VSI, than a fish with a lower condition factor, both with the same body weight.

4.3.1 YELLOWTAIL (*Seriola quinqueradiata*)

Although the condition factor ranged from 1.1 to 1.9, around 74% of the population varied between 1.1 and 1.7, so it was in this area where the effects of the variation in K were studied.

The reduction in the proportion of carcass, is probably not due only to the reciprocal increase in the proportion of viscera, but also to the relative reduction of certain tissues, such as, head, skin, bones, etc. In this species the decreasing growth of those tissues (head, bones, etc.) with increasing condition is obvious, because even with a decrease in the proportion of carcass, the percentage of fillet increased, i. e., the amount of muscle increased. On the other hand, a decrease in ash content was observed with the increase in body weight (chapter 3.1.2). This trend was also reported for rainbow trout by Weatherley and Gill (1989, quoting Shearer) and for red seabream by Oikawa *et al.* (1992), which means that the fish with the lowest condition factor (with the same weight) has, proportionally a greater amount of tissues, such as, head, skin, bones and scales.

The disproportionate decrease of head, bones, etc., with increasing body weight and the proportionally greater amount of visceral organs are the responsible for the decrease in the percentage of dressed weight with condition factor.

As it was possible to observe in chapter 3.1.1, the organs and tissues responsible for the increase in VSI with body weight, were the liver and maybe some mesenteric fat (due to the increase verified in the percentage of gut).

Although fat content increases with size and level of production, the tissues where surplus energy accumulates differ from species to species. Energy can be stored as visceral depots (primary lipid storage in salmonids), in muscle tissue or in the liver (Weatherley and Gill, 1989). The increasing amounts of fat in the body, with increase in condition factor, was probably due not only to the increase of some fat in the viscera, but mainly to increased deposition of fat in the muscle. This can be seen through the increased proportion of fat deposited in the fillet, with the increase in that index.

This relationship indicates that muscle is the principal site of storage of fat in yellowtail. The increase in the proportion of fillet with condition factor, in yellowtail, is mainly due to the increase in the amount of fat in the fillet. Besides that, the decrease in the proportion of protein in the fillet, can be related to the increasing proportion of fat. Therefore, the pattern of growth of protein can serve as an indication that muscle is a preferential site of fat deposition, at least in this species. Species such as, plaice, *Pleuronectes platessa* L., also store fat in the muscle (Dawson and Grimm, 1980).

For yellowtail it is advantageous to induce growth and keep fish in good condition, because the visceral losses are small (5-6%). Nevertheless, it is important to get the appropriate level of fat and also of protein, due to the proportional decrease of protein with increasing condition factor. Obviously the proper levels of fat content will depend on the target market. As pointed out by Fauconneau *et al.* (1995), the development of fat in the flesh could play an important role not only in the visual appearance of the flesh and the processing yield but also its taste.

4.3.2 AMBERJACK (*Seriola purpurascens*)

The present species showed a condition factor range from 1.65 to 2. Nevertheless, 53% of the population had a condition factor higher than 1.8, which is the point where occurred a reversal of the trends in some of the parameters.

The nature of the sampling is probably one of the factors responsible for this reversal of trends, mainly because the size range covered and the number of fish were too limited. On the other hand, because almost nothing is known about the rearing conditions of the Japanese species, this situation can be a limitative factor in the interpretation of the results. For instance, it is common among the Japanese aquaculturists to stop feeding the fish for a certain period, due to the high feeding costs associated with these big species (Talbot, personal communication). This situation induces great changes in fish body and consequently in the condition factor, as it was reported by other researchers (Cui and Wootton, 1988; McLeese and Moon, 1989; Mustafa *et al.*, 1991; Garcia Garcia *et al.*, 1993).

Because 95% of the population had a condition factor of 1.65 to 1.9, this is the range in which the variations in the body traits with changes in condition factor, were studied.

In this range of condition factor a decrease was observed in the percentage of dressed weight and the reciprocal increase in the proportion of viscera, with increasing condition factor, which is in agreement with what happened with yellowtail and for the same reasons. Probably there was a reduction in the proportion of certain tissues, such as, head, skin, bones, etc., with increasing condition. In chapter 3.1.2 it was possible to observe a decrease in the percentage of ash content with increasing body weight. This reduction in the proportion of certain tissues with body weight were reported by other researchers (Weatherley and Gill, 1989; Oikawa *et al.*, 1992).

Although not statistically significant, a trend toward a slight increase in VSI, %gut and HSI with body weight was shown by this species.

The decrease in the percentage of dressed weight was followed not only by the reduction in the proportion of head, bones, etc., but also by a decrease in the percentage of fillet. Responsible for this decrease was the decrease in the amount of fat in the muscle, which can be observed by the decreasing amounts of fat that are deposited in the muscle. Since fat content decreased with condition factor, the probably cause was a change in feeding. Because the level of fat achieved by a fish toward the end of the feeding period is the result of the feeding condition and adequately reflects the food supply during the period (Jensen, 1980), somewhere during the grow out phase, there was changes in feeding practices of the fish. Fish had to use energy stored in the muscle to cover their needs.

Since the decrease in fat content in the whole fish was follow by the decreasing amounts of fat deposited in the fillet, this means that also for this species muscle is probably the preferential site of fat deposition.

The analyse of the 3D scatter plots for amberjack showed that there was variations in the rearing conditions during the grow out phase, that in a way modified the normal trends of the different parameters that was expected to be occur. It seems that amberjack follows the same patterns of growth as yellowtail, by analysing the trends of the body traits with body weight (not statistically significative) (chapter 3.1), although that was not possible to see in the present chapter due to the reasons already pointed out.

4.3.3 RED SEABREAM (*Pagrus major*)

Also for red seabream, above a condition factor of 2.4 (ranging from 2.0 to 2.6), there was an inversion in the trends of growth of the percentage of dressed weight and VSI. Since 93% of the population was below this value of condition factor, the 3D scatter plots were analysed imposing this value as a limit.

Several factors could be the responsible for the lack of significant results, as was observed in amberjack. The characteristic of sampling, which in this case could be due to the heterogeneity of the distribution of the sample, i.e., a lack of a greater number of fish in the

middle sizes; the possibility that fish had origin in different aquacultures, which means that they could have been cultured under different rearing conditions; the fact that fish could have been for a certain period without being fed; and because the bigger fish had already reached and surpassed the maturity size, which means that maybe some of the fish had been submitted to the changes inherent in the reproductive cycles.

Once more, the inverse relationship between the percentage of dressed weight and VSI was observed. The decrease in the proportion of carcass could be related, either with a decrease in the proportion of other tissues, or with the decrease in the percentage of fillet, although neither of these results were significant.

The increase in the VSI with the increase in condition factor, could result from the increasing proportion of visceral fat, although this result was not significant, and that increase could only be seen in fish under 1800g. The changes in VSI can also be observed analysing the growth of the different visceral organs with body weight, because even with no significant increase in the proportion of visceral fat, this species showed a decrease in percentage of liver and gut, with increasing body weight. Oikawa *et al.* (1991), reported a not significant decrease in the relative growth of visceral fat in red seabream.

The remaining relationships, particularly concerning the patterns of growth for fat content and the proportion of fat that is deposited in the muscle, do not permit conclusions, in a way to define the sites of fat stores for red seabream. Because the percentage of fillet decreased and there was not a definite pattern of growth of fat content, with condition factor, it is not possible to know if red seabream uses preferentially the muscle or the viscera to deposit surplus energy. The relationship between the condition factor and body fat in cultured red seabream, *Pagrus major*, was obtained by Kora *et al.* (1990). Weights of both viscera and muscle were significantly and positively correlated with condition factor. The fat content in the viscera was also positively correlated with condition factor, while the fat content in the muscle showed no correlation. The lean mass weight in the muscle, however, showed positive correlation. These authors suggested that the condition factor in cultured red seabream is a physique index which indicates the quantity of lean mass in

muscles and of fat in the visceral part, but is not an index for fat content in the whole fish body.

4.3.4 SEABREAM (*Sparus aurata*)

This species in common with those already mentioned shows a reversal of trends in some of the analysed parameters, above a certain value of condition factor. With a condition factor range from 1.8 to 2.7, 80% of the population presents a condition higher than 2.2, that is why the different 3D scatter plots were interpreted above this value.

Although seabream maintains the inverse relationship between the percentage of dressed weight and VSI, as showed for the other species, the variation in these two parameters with the increasing condition factor is less pronounced. This means that an increase in the condition factor only changes slightly the proportion of carcass and viscera.

The increase in the VSI was a function of the increase in the proportion of liver and of visceral fat, as was mentioned in the former chapter. Although the levels of fat increased with the increase in condition, not too much can be said about the sites of fat stores. It is obvious that the increased deposition of fat in the visceral cavity will play an important role in the increase of fat in the whole fish. Nevertheless, the amount of fat that was deposited in the viscera was small (mean of 0.9% of total weight, table 3.1). To know what happened with the deposition of fat in the muscle, the fillet should be removed and analysed separately.

Comparing wild and cultured seabream, *Sparus aurata*, Sañudo *et al.* (1993), reported higher values of condition factor for the cultured fish, and consequently, higher values of HSI and fat content.

A great amount of fat can be stored in a fish of this species in good condition, without the risk of having great visceral losses.

4.3.5 SEABASS (*Dicentrarchus labrax*)

Seabass showed a very define relationship among the different parameters, with no switch of trends, thus the 3D scatter plot was interpreted for all the condition factor range (from 1.1 to 1.6).

Once more, the inverse relationship between the percentage of dressed weight and VSI is present in this species. Nevertheless, variations in the condition factor induced marked changes in these two parameters.

The trend toward a decrease in the proportion of tissues, such as bones, scales, etc., with increasing condition, responsible in part for the decrease in the percentage of carcass, can be seen through the decrease in ash content with increasing body weight (chapter 3.1.2).

In this species the importance of the visceral fat to the increase in the proportion of VSI and to the consequent decrease in the dressing weight is clear. In studies with seabass, Mustafa *et al.* (1991), conclude that the highest value of K in October was attributed to the fishes physiological preparations in autumn, for the overwintering phase, and that the hepatosomatic index gives a more accurate description of growth in immature fish, due to the importance of liver as a storage organ for fat. Nevertheless, in the present study, HSI did not show any significative relationship with body weight. On the other hand, the visceral fat (mean 6.24%) was responsible for 57% of the total viscera weight. For this reason, and even not knowing the behaviour of deposition of fat in the muscle, it is possible to conclude that seabass deposit a large amount of energy as visceral fat. The viscera as the principal site stores of fat has also been reported for rainbow trout (Weatherley and Gill, 1989), brown trout and Arctic charr (Jensen, 1980).

The variations in K, due to the influence of external factors, such as, for instance, ration size, can result from variations in the VSI. In juveniles of seabass, Hidalgo *et al.* (1989), reported a decrease in VSI with the decrease in ration size.

In the present work, the amount of fat is little affected by the condition factor, and the small changes in this component by variations in condition, are probably induced by the increase in visceral fat content.

Because the abdominal fat is a waste product, in this species when growth is induced so as to produce fish with high condition, the growth of the waste products are induced as well. In markets where fish is sold gutted, a great part of the fish weight is lost in the visceral products. For instance, in the present sample, a fish with 400g and a condition factor of 1.4, has a visceral loss of more than 12% of its total weight. On the other hand, in markets where fish is sold ungutted, what looks advantageous to the aquaculturist, is disadvantageous to the consumers. So from a marketing point of view less abdominal fat may also be of importance (Gjerde and Schaeffer, 1989). To the benefit of all concerned it may be of importance to reduce the amount of fat deposited, as this may improve feed efficiency.

5 CONCLUSIONS

The definite patterns of growth of some of the parameters with body weight, allowed the determination of regression equations. Thus, the weight or percentage of an organ or tissues can be estimated with a high degree of accuracy from the single knowledge of body weight. Parameters of interest to the aquaculturist, such as percentage of carcass, VSI, percentage of visceral fat and percentage of total fat in the body, can be estimated as a function of body weight, when all that is required is a good approximation.

The condition factor is an useful index to relate with the different production parameters, because since this index relates weight with length, variations in condition rapidly translate changes in the rearing conditions and consequently in the production level. Two fishes with the same weight (or length), although with different lengths (or weights), have necessarily different condition factors and consequently different value of body traits. These changes in the body traits are much more easy to observe using the condition factor rather than the weight or length alone.

Independently of the species, the fish growth induces a decrease in the amount of carcass, with the consequently increase in the proportion of visceral organs. However, the relative importance of this growth in the different species, will depend on the site of preferential energy deposition. This means that if fat increases with body weight in a species, it will be the partitioning of this tissue in the body that will play an important role in terms of production and quality of the final product.

1) YELLOWTAIL (*Seriola quinqueradiata*)-The increase in the proportion of fillet, even with a decrease in the percentage of carcass, it is because muscle is the principal site of fat stores, which means that this species has small visceral losses due to gutting. Thus, either a bigger fish or a fish in better condition has a greater amount of fat. On the other hand, the same fish has proportionally less protein. It is, therefore, necessary to find the correct relative proportions of fat and protein, which depends on the markets.

The lack of background information concerning the rearing conditions of the Japanese species, affected the interpretation of the results, especially concerning amberjack and red seabream. The small sample and limited size ranges of amberjack, the heterogeneous distribution of sizes, lacking some size ranges, of red seabream, together with the fact that nothing is known about where exactly the fish were cultured (same/different farm; same/different feeds), prevent conclusions about the culture of these species.

AMBERJACK (*Seriola purpurascens*)- It appears that amberjack follows the same pattern of growth as yellowtail. If this is the case, it is important to culture this species in a way to have fish in good condition.

RED SEABREAM (*Pagrus major*)- It seems that for this species the viscera plays an important role as a site of fat stores, nevertheless no conclusions can be made on this species.

SEABREAM (*Sparus aurata*) and SEABASS (*Dicentrarchus labrax*)-Although both species get fatter as they grow, it is difficult to identify the principal site of fat stores. Nevertheless, the great amount of fat deposited in the abdominal cavity of seabass (57% of the viscera weight is visceral fat), is an indication that viscera could be the principal site for this species. Since visceral fat is a waste product, as higher is the condition factor, as greater are the visceral losses. So from a market point of view maybe it is important to reduce the abdominal fat.

Further studies will be necessary to find the correct answers to some of the questions that were not resolved, in order to quantify the changes in carcass quality. First of all it is important to get more information about the rearing conditions of the species. Bigger samples covering more sizes, will be necessary for studies of amberjack and red seabream. Analyses of the fillet of seabream and seabass, will need further investigation to determine where fat is preferentially deposited.

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APPENDIX

BIOLOGICAL MEASUREMENTS

Table I. Yellowtail - total weight, length, K, dressed weight, % dressed weight, fillet weight and % of fillet

Fish code	Size range, g	Sex	Total weight, g	Length, cm	K	Dressed weight, g	% Dressed weight	Fillet weight, g	% Fillet
Y10-1W	1000-2000	F	1085,0	44,2	1,26	1005,0	92,6	305,0	58,1
Y10-2W		F	1370,0	46,8	1,34	1255,0	91,6	375,0	56,4
Y9-57W		F	1015,0	43,5	1,23	940,0	92,6	285,0	57,6
Y10-58W		F	1450,0	48,5	1,27	1365,0	94,1	425,0	59,0
Y10-59W		F	1490,0	47,8	1,36	1390,0	93,3	430,0	58,9
Y10-65W		M	1584,0	47,4	1,49	1374,0	86,7	414,0	57,0
Y9-66W		M	1118,0	45,4	1,19	1054,0	94,3	299,0	54,5
Y10-67W		F	1389,0	47,7	1,28	1303,0	93,8	392,0	57,2
Y9-68W		M	1232,0	45,2	1,33	1096,0	89,0	311,0	53,9
Y10-70W		M	1347,0	47,9	1,23	1280,0	95,0	364,0	55,2
Y11-86W		M	1810,0	49,4	1,50	1680,0	92,8	520,0	58,4
Y11-94W		F	1910,0	50,0	1,53	1790,0	93,7	550,0	58,2
Y11-95W		M	1990,0	49,4	1,65	1850,0	93,0	590,0	59,9
Y11-101W		M	1950,0	49,5	1,61	1830,0	93,8	560,0	58,0
Y13-60W	2000-3000	F	2965,0	56,5	1,64	2720,0	91,7	890,0	61,3
Y13-62W		F	2900,0	57,9	1,49	2660,0	91,7	795,0	56,7
Y13-63W		F	2998,0	58,7	1,48	2754,0	91,9	878,0	59,9
Y11-87W		M	2070,0	50,0	1,66	1930,0	93,2	600,0	58,5
Y12-88W		F	2270,0	49,7	1,85	2120,0	93,4	700,0	62,2
Y11-89W		M	2130,0	50,9	1,62	1940,0	91,1	610,0	59,2
Y11-90W		F	2100,0	51,1	1,57	1980,0	94,3	630,0	60,6
Y11-91W		M	2140,0	52,0	1,52	1990,0	93,0	630,0	59,7
Y11-92W		M	2100,0	49,8	1,70	1950,0	92,9	610,0	59,2
Y12-93W		M	2300,0	51,3	1,70	2110,0	91,7	660,0	58,7
Y12-96W		F	2410,0	53,2	1,60	2250,0	93,4	730,0	61,3
Y12-97W		M	2410,0	53,6	1,57	2270,0	94,2	700,0	60,3
Y12-98W		M	2430,0	53,0	1,63	2260,0	93,0	700,0	58,3
Y12-99W		F	2280,0	51,3	1,69	2120,0	93,0	665,0	59,5
Y12-100W	F	2320,0	50,9	1,76	2110,0	90,9	670,0	59,3	
Y13-3W	3000-4000	F	3125,0	59,6	1,48	2870,0	91,8	910,0	59,4
Y13-4W		F	3235,0	59,2	1,56	2975,0	92,0	945,0	59,5
Y13-5W		F	3400,0	59,5	1,61	3150,0	92,6	970,0	57,7
Y13-6W		F	3590,0	61,1	1,57	3265,0	90,9	1065,0	59,7
Y14-7W		F	3550,0	60,0	1,64	3265,0	92,0	1045,0	60,6
Y13-8W		F	3110,0	56,2	1,75	2850,0	91,6	820,0	54,3
Y14-11W		F	3475,0	57,7	1,81	3185,0	91,7	990,0	58,8
Y13-61W		F	3200,0	59,0	1,56	2915,0	91,1	920,0	59,8
Y14-64W		F	3533,0	60,0	1,64	3297,0	93,3	1029,0	58,7
Y14-69W		F	3287,0	57,8	1,70	3025,0	92,0	1001,0	61,7
Y14-71W		F	3304,0	57,8	1,71	3087,0	93,4	958,0	58,8
Y14-72W		M	3600,0	60,1	1,66	3320,0	92,2	1030,0	59,0
Y14-73W		M	3600,0	59,2	1,74	3260,0	90,6	1010,0	58,4
Y15-74W		M	3750,0	60,6	1,69	3460,0	92,3	1060,0	58,4
Y15-80W	M	3930,0	62,0	1,65	3590,0	91,3	1140,0	59,2	
Y15-82W	F	3980,0	62,0	1,67	3550,0	89,2	1050,0	55,7	
Y15-9W	4000-5000	F	4010,0	61,1	1,76	3595,0	89,7	1085,0	56,4
Y16-10W		F	4300,0	62,5	1,76	3990,0	92,8	1265,0	59,3
Y16-75W		F	4450,0	61,8	1,89	4100,0	92,1	1360,0	62,7
Y16-76W		F	4620,0	64,3	1,74	4160,0	90,0	1350,0	60,7
Y16-77W		F	4650,0	64,5	1,73	4140,0	89,0	1290,0	58,6
Y16-78W		M	4290,0	62,8	1,73	3930,0	91,6	1250,0	59,8
Y16-79W		F	4440,0	64,4	1,66	4040,0	91,0	1220,0	56,5
Y15-81W		M	4160,0	61,5	1,79	3830,0	92,1	1230,0	60,0
Y17-83W		F	5200,0	66,7	1,75	4750,0	91,3	1510,0	60,4
Y15-84W		M	4160,0	63,6	1,62	3820,0	91,8	1170,0	58,4
Y15-85W		M	4060,0	60,7	1,82	3680,0	90,6	1180,0	59,9
Y16-102W		M	4250,0	63,0	1,70	3920,0	92,2	1220,0	58,2

BIOLOGICAL MEASUREMENTS

Table II. Red Seabream - total weight, length, K, dressed weight, % dressed weight, fillet weight and % of fillet

Fish code	Size range, g	Sex	Total weight, g	Length, cm	K	Dressed weight, g	% Dressed weight	Fillet weight, g	% Fillet	
S10-1W	750-1500	F	820,0	33,5	2,18	750,0	91,5	230,0	56,8	
S13-2W		M	1180,0	37,7	2,20	1110,0	94,1	350,0	60,3	
S12-3W		F	1080,0	36,0	2,31	1010,0	93,5	310,0	57,9	
S15-4W		M	1390,0	40,2	2,14	1300,0	93,5	410,0	59,9	
S12-7W		F	1110,0	36,3	2,32	1000,0	90,1	310,0	56,9	
S14-14W		M	1330,0	38,3	2,37	1180,0	88,7	350,0	53,4	
S11-15W		F	960,0	36,0	2,06	900,0	93,8	270,0	56,8	
S11-17W		F	980,0	35,0	2,29	900,0	91,8	280,0	58,3	
S13-18W		F	1200,0	37,5	2,28	1100,0	91,7	340,0	57,6	
S11-21W		F	1010,0	35,4	2,28	890,0	88,1	270,0	54,5	
S11-22W		F	1010,0	35,4	2,28	900,0	89,1	280,0	56,0	
S11-23W		M	970,0	34,7	2,32	860,0	88,7	260,0	54,2	
S11-24W		M	990,0	34,9	2,33	890,0	89,9	280,0	57,1	
S12-25W		F	1070,0	36,0	2,29	970,0	90,7	310,0	58,5	
S21-5W		1500-2000	F	1960,0	44,4	2,24	1790,0	91,3	570,0	58,5
S17-6W			F	1640,0	40,0	2,56	1520,0	92,7	470,0	57,7
S21-8W	F		1970,0	44,0	2,31	1810,0	91,9	570,0	58,8	
S20-9W	F		1900,0	43,0	2,39	1770,0	93,2	560,0	59,6	
S19-10W	F		1810,0	43,0	2,28	1660,0	91,7	530,0	59,2	
S20-11W	F		1890,0	43,5	2,30	1740,0	92,1	560,0	59,9	
S19-12W	F		1760,0	43,6	2,12	1620,0	92,0	500,0	57,5	
S18-13W	M		1730,0	43,7	2,07	1620,0	93,6	510,0	59,6	
S21-16W	M		2060,0	45,5	2,19	1910,0	92,7	610,0	59,8	
S19-19W	F		1840,0	42,5	2,40	1715,0	93,2	510,0	56,0	
S20-20W	F		1890,0	43,0	2,38	1750,0	92,6	530,0	56,4	
S19-26W	F		1810,0	44,3	2,08	1650,0	91,2	510,0	57,0	
S21-27W	M		1960,0	44,4	2,24	1760,0	89,8	550,0	56,7	
S21-28W	F		2070,0	46,1	2,11	1860,0	89,9	570,0	56,2	
S20-29W	F		1930,0	43,2	2,39	1720,0	89,1	530,0	55,2	
S20-30W	F		1880,0	43,5	2,28	1680,0	89,4	500,0	53,8	

Table III. Amberjack - total weight, length, K, dressed weight, % dressed weight, fillet weight and % of fillet

Fish code	Size range, g	Sex	Total weight, g	Length, cm	K	Dressed weight, g	% Dressed weight	Fillet weight, g	% Fillet
K11-1W	1350-2300	F	1830,0	45,6	1,93	1710,0	93,4	560,0	61,5
K10-2W		M	1390,0	41,5	1,94	1300,0	93,5	400,0	58,8
K11-3W		M	1820,0	45,3	1,96	1720,0	94,5	570,0	63,3
K10-4W		F	1350,0	43,0	1,70	1280,0	94,8	390,0	58,6
K10-5W		M	1680,0	45,4	1,80	1570,0	93,5	520,0	63,0
K11-6W		F	2000,0	48,4	1,76	1880,0	94,0	600,0	60,9
K11-7W		M	2090,0	47,7	1,93	1970,0	94,3	630,0	60,9
K12-8W		M	2290,0	51,4	1,69	2160,0	94,3	690,0	61,1
K10-9W		M	1550,0	44,7	1,74	1470,0	94,8	470,0	61,4
K10-10W		M	1570,0	44,3	1,81	1460,0	93,0	470,0	60,6
K10-11W		F	1720,0	45,0	1,89	1620,0	94,2	530,0	62,0
K10-12W		M	1670,0	44,9	1,84	1580,0	94,6	500,0	60,6
K10-13W		M	1690,0	46,0	1,74	1610,0	95,3	510,0	60,7
K11-14W		M	1870,0	47,5	1,74	1760,0	94,1	560,0	60,5
K10-15W		M	1630,0	44,9	1,80	1530,0	93,9	480,0	59,6
K10-16W		F	1680,0	44,4	1,92	1580,0	94,0	500,0	60,2
K11-17W		F	2030,0	47,7	1,87	1920,0	94,6	610,0	60,7
K10-18W		M	1540,0	43,2	1,91	1440,0	93,5	450,0	59,2
K11-19W		F	1830,0	46,9	1,77	1730,0	94,5	560,0	61,9

BIOLOGICAL MEASUREMENTS

Table IV. Seabream - total weight, length, K, dressed weight and % dressed weight

Fish code	Size range, g	Sex	Total weight, g	Length, cm	K	Dressed weight, g	% Dressed weight
D2-1	200	M	155,1	19,0	2,26	145,4	93,7
D2-2		M	189,5	20,3	2,27	177,2	93,5
D2-3		M	201,0	20,6	2,30	186,6	92,8
D2-4		M	218,3	21,0	2,36	201,2	92,2
D2-5		M	193,7	21,0	2,09	178,7	92,3
D2-6		M	202,0	21,0	2,18	187,6	92,9
D2-7		M	201,5	20,7	2,27	189,2	93,9
D2-8		M	227,9	21,8	2,20	213,9	93,9
D2-9		M	162,5	19,1	2,33	153,2	94,3
D2-10		M	191,9	21,2	2,01	175,9	91,7
D2-11		M	201,1	21,1	2,14	189,2	94,1
D2-12		M	171,7	19,0	2,50	160,9	93,7
D2-13		M	224,1	21,3	2,32	211,1	94,2
D2-14		M	168,9	19,5	2,28	159,3	94,3
D2-15		M	168,3	19,9	2,14	153,5	91,2
D3-1	300	M	306,7	23,5	2,36	281,4	91,8
D3-2		M	307,8	23,9	2,25	279,7	90,9
D3-3		M	300,2	23,4	2,34	277,4	92,4
D3-4		M	282,5	23,5	2,18	264,1	93,5
D3-5		M	316,0	24,0	2,29	298,7	94,5
D3-6		M	306,2	23,8	2,27	285,1	93,1
D3-7		M	279,2	23,0	2,29	258,1	92,4
D3-8		M	285,7	22,9	2,38	262,4	91,8
D3-9		M	269,8	22,1	2,50	248,1	92,0
D3-10		M	314,6	23,8	2,33	292,6	93,0
D3-11		M	302,7	22,7	2,59	283,2	93,6
D3-12		M	284,5	23,1	2,31	266,7	93,7
D3-13		M	294,4	25,0	1,88	273,7	93,0
D3-14		M	292,0	24,1	2,09	272,8	93,4
D3-15		M	318,9	23,7	2,40	297,7	93,4
D4-1	400	M	406,7	25,7	2,40	381,9	93,9
D4-2		M	406,4	25,7	2,39	370,5	91,2
D4-3		M	394,1	24,9	2,55	366,6	93,0
D4-4		M	370,7	24,9	2,40	343,6	92,7
D4-5		M	403,6	26,4	2,19	376,7	93,3
D4-6		M	389,2	25,9	2,24	363,3	93,3
D4-7		M	420,1	26,3	2,31	396,5	94,4
D4-8		M	351,0	24,5	2,39	327,1	93,2
D4-9		M	415,0	26,3	2,28	380,2	91,6
D4-10		M	400,4	25,9	2,30	364,7	91,1
D4-11		M	398,8	25,0	2,55	368,5	92,4
D4-12		M	385,0	24,9	2,49	352,4	91,5
D4-13		M	402,2	26,0	2,29	374,1	93,0
D4-14		M	365,9	24,0	2,65	334,6	91,4
D4-15		M	400,9	25,5	2,42	367,5	91,7
D5-1	500	M	476,7	26,5	2,56	435,3	91,3
D5-2		M	495,6	27,7	2,33	455,2	91,8
D5-3		M	509,5	27,5	2,45	457,6	89,8
D5-4		M	453,2	27,4	2,20	426,3	94,1
D5-5		M	461,7	26,7	2,43	432,5	93,7
D5-6		M	479,6	26,4	2,61	446,5	93,1
D5-7		M	463,7	26,8	2,41	426,4	92,0
D5-8		M	471,1	26,0	2,68	424,5	90,1
D5-9		M	455,1	26,9	2,34	406,1	89,2
D5-10		M	471,3	27,4	2,29	426,2	90,4
D5-11		M	474,3	28,2	2,11	435,6	91,8
D5-12		M	485,1	27,8	2,26	445,8	91,9
D5-13		M	466,3	26,5	2,51	425,3	91,2
D5-14		M	456,7	27,0	2,32	419,4	91,8
D5-15		M	455,6	26,0	2,59	412,2	90,5

BIOLOGICAL MEASUREMENTS

Table V. Seabass - total weight, length, K, dressed weight and % dressed weight

Fish code	Size range, g	Sex	Total weight, g	Length, cm	K	Dressed weight, g	% Dressed weight
R1-1	100	0	79,9	18,0	1,37	72,8	91,1
R1-2		0	90,6	18,9	1,34	84,8	93,6
R1-3		0	108,3	20,4	1,28	95,4	88,1
R1-4		0	101,3	19,7	1,32	90,1	88,9
R1-5		0	88,0	19,4	1,21	78,2	88,9
R1-6		0	103,9	20,2	1,26	92,2	88,7
R1-7		0	75,6	18,5	1,19	67,7	89,6
R1-8		0	103,0	18,8	1,55	92,4	89,7
R1-9		0	115,9	20,9	1,27	100,7	86,9
R1-10		0	99,9	19,7	1,31	86,4	86,5
R1-11		0	107,1	20,2	1,30	91,3	85,2
R1-12		0	91,0	19,3	1,27	84,0	92,3
R1-13		0	105,8	20,1	1,30	95,1	89,9
R1-14		0	97,8	19,6	1,30	87,2	89,2
R1-15		0	129,3	21,5	1,30	111,7	86,4
R2-1	200	M	192,5	23,8	1,43	167,7	87,1
R2-2		M	183,8	24,0	1,33	160,3	87,2
R2-3		F	180,2	23,6	1,37	155,5	86,3
R2-4		M	190,0	24,2	1,34	165,1	86,9
R2-5		F	192,0	23,6	1,46	169,2	88,1
R2-6		M	178,7	24,4	1,23	155,1	86,8
R2-7		F	203,9	25,5	1,23	182,5	89,5
R2-8		M	186,6	24,3	1,30	165,1	88,5
R2-9		M	173,9	24,4	1,20	161,4	92,8
R2-10		M	184,2	23,8	1,37	156,7	85,1
R2-11		M	184,7	24,2	1,30	157,7	85,4
R2-12		M	193,4	24,8	1,27	169,4	87,6
R2-13		M	172,0	23,8	1,28	150,0	87,2
R2-14		M	186,6	23,7	1,40	165,6	88,7
R2-15		M	199,4	24,7	1,32	180,2	90,4
R3-1	300	M	295,5	27,6	1,41	257,3	87,1
R3-2		M	290,9	27,7	1,37	256,3	88,1
R3-3		F	287,3	27,3	1,41	252,4	87,9
R3-4		M	278,2	27,7	1,31	250,3	90,0
R3-5		M	319,3	28,2	1,42	276,0	86,4
R3-6		M	307,0	27,9	1,41	272,3	88,7
R3-7		M	293,2	27,9	1,35	249,6	85,1
R3-8		M	303,0	28,5	1,31	270,8	89,4
R3-9		M	308,9	27,5	1,49	256,9	83,2
R3-10		F	306,8	28,9	1,27	269,8	87,9
R3-11		M	280,4	27,8	1,31	243,3	86,8
R3-12		M	320,8	28,5	1,39	277,1	86,4
R3-13		M	284,4	27,6	1,35	252,7	88,9
R3-14		M	293,3	27,5	1,41	233,5	79,6
R3-15		M	267,4	27,9	1,23	254,5	95,2
R4-1	400	M	365,2	28,5	1,58	315,7	86,4
R4-2		M	383,2	29,3	1,52	329,7	86,0
R4-3		F	403,9	31,0	1,36	355,7	88,1
R4-4		M	397,9	29,8	1,50	331,2	83,2
R4-5		M	367,2	29,2	1,47	309,4	84,3
R4-6		M	376,7	28,8	1,58	326,2	86,6
R4-7		M	388,4	29,6	1,50	327,1	84,2
R4-8		F	387,1	30,3	1,39	340,7	88,0
R4-9		M	415,2	30,6	1,45	355,2	85,5
R4-10		M	407,4	30,9	1,38	344,7	84,6
R4-11		M	389,5	31,3	1,27	337,4	86,6
R4-12		M	394,5	29,8	1,49	338,3	85,8
R4-13		M	398,4	29,9	1,49	337,2	84,6
R4-14		F	382,1	30,3	1,37	337,7	88,4
R4-15		F	375,5	29,8	1,42	333,1	88,7
R5-1	500	M	478,5	32,0	1,46	421,9	88,2
R5-2		F	469,9	32,7	1,34	406,8	86,6
R5-3		F	500,6	32,4	1,47	423,7	84,6
R5-4		F	470,1	33,2	1,28	415,4	88,4
R5-5		F	476,1	32,3	1,41	406,8	85,4
R5-6		F	472,1	31,5	1,51	414,6	87,8
R5-7		M	471,4	32,9	1,32	412,4	87,5
R5-8		M	506,9	32,2	1,52	434,8	85,8
R5-9		F	476,7	33,0	1,33	425,7	89,3
R5-10		F	510,0	33,0	1,42	440,6	86,4
R5-11		F	501,3	32,8	1,42	445,8	88,9
R5-12		M	486,4	32,2	1,46	425,1	87,4
R5-13		F	525,7	34,2	1,31	459,8	87,5
R5-14		F	479,9	34,8	1,14	424,4	88,4
R5-15		F	468,7	32,3	1,39	405,7	86,6

BIOLOGICAL MEASUREMENTS

Table VI. Yellowtail - organs weight and organs index

Fish code	Size range, g	Liver weight, g	LSI	Gonads weight, g	GSI	Gut weight,g	% Gut	Gill,g	Total viscera, g	VSI
Y10-1W	1000-2000	9,31	0,86	4,05	0,37	28,20	2,60	32,36	41,56	3,83
Y10-2W		13,91	1,02	5,31	0,39	48,44	3,54	38,50	67,66	4,94
Y9-57W		10,97	1,08	5,05	0,50	33,91	3,34	27,27	49,93	4,92
Y10-58W		16,92	1,17	6,88	0,47	47,78	3,30	38,06	71,58	4,94
Y10-59W		16,90	1,13	5,60	0,38	50,09	3,36	45,35	72,59	4,87
Y10-65W		22,31	1,41	4,53	0,29	58,40	3,69	36,24	84,31	5,32
Y9-66W		11,21	1,00	3,66	0,33	37,92	3,39	31,74	52,25	4,67
Y10-67W		15,22	1,10	5,21	0,38	54,66	3,94	34,88	74,70	5,38
Y9-68W		19,46	1,58	4,96	0,40	43,61	3,54	18,53	67,68	5,49
Y10-70W		8,67	0,64	4,03	0,30	37,15	2,76	31,55	49,62	3,68
Y11-86W		16,81	0,93	2,01	0,11	93,32	5,16	41,99	110,93	6,13
Y11-94W		22,68	1,19	7,90	0,41	72,86	3,81	60,65	102,86	5,39
Y11-95W		30,61	1,54	2,90	0,15	90,35	4,54	46,31	122,72	6,17
Y11-101W		22,35	1,15	2,10	0,11	83,06	4,26	45,99	106,84	5,48
Y13-60W	2000-3000	45,44	1,53	16,15	0,54	114,78	3,87	77,92	176,37	5,95
Y13-62W		39,31	1,36	17,23	0,59	101,84	3,51	67,65	156,08	5,38
Y13-63W		46,52	1,55	18,85	0,63	131,36	4,38	71,11	196,73	6,56
Y11-87W		23,47	1,13	2,32	0,11	93,58	4,52	46,16	118,84	5,74
Y12-88W		36,22	1,60	4,50	0,20	94,12	4,15	37,36	133,94	5,90
Y11-89W		31,54	1,48	3,04	0,14	92,91	4,36	55,21	129,11	6,06
Y11-90W		19,76	0,94	6,73	0,32	84,47	4,02	52,28	109,68	5,22
Y11-91W		31,58	1,48	2,16	0,10	93,01	4,35	52,54	127,34	5,95
Y11-92W		29,07	1,38	2,32	0,11	98,62	4,70	55,28	128,70	6,13
Y12-93W		53,78	2,34	2,34	0,10	101,00	4,39	62,07	156,44	6,80
Y12-96W		33,75	1,40	7,14	0,30	107,30	4,45	61,53	148,54	6,16
Y12-97W		23,87	0,99	2,55	0,11	95,96	3,98	62,24	122,38	5,08
Y12-98W		43,04	1,77	2,62	0,11	103,24	4,25	52,62	148,49	6,11
Y12-99W		22,47	0,99	7,88	0,35	96,04	4,21	56,15	124,93	5,48
Y12-100W	39,22	1,69	7,13	0,31	103,61	4,47	56,62	149,21	6,43	
Y13-3W	3000-4000	40,57	1,30	21,27	0,68	122,92	3,93	80,62	184,76	5,91
Y13-4W		41,06	1,27	19,02	0,59	124,09	3,84	84,41	184,17	5,69
Y13-5W		41,72	1,23	23,73	0,70	134,76	3,96	98,32	200,21	5,89
Y13-6W		54,26	1,51	22,58	0,63	153,51	4,28	88,16	230,35	6,42
Y14-7W		27,45	0,77	17,45	0,49	155,92	4,39	90,64	200,82	5,66
Y13-8W		10,64	0,34	16,28	0,52	133,73	4,30	80,10	160,65	5,17
Y14-11W		48,10	1,38	7,85	0,23	126,12	3,63	99,61	182,07	5,24
Y13-61W		68,38	2,14	16,81	0,53	145,41	4,54	84,22	230,60	7,21
Y14-64W		51,96	1,47	19,52	0,55	152,90	4,33	87,31	233,00	6,59
Y14-69W		57,93	1,76	17,22	0,52	138,58	4,22	69,80	213,00	6,48
Y14-71W		50,71	1,53	18,94	0,57	131,50	3,98	67,31	199,52	6,04
Y14-72W		43,50	1,21	6,05	0,17	157,56	4,38	80,87	205,69	5,71
Y14-73W		60,30	1,68	6,03	0,17	146,37	4,07	94,49	211,49	5,87
Y15-74W		50,18	1,34	7,82	0,21	150,43	4,01	89,46	207,72	5,54
Y15-80W	77,56	1,97	10,32	0,26	184,49	4,69	97,64	270,27	6,88	
Y15-82W	69,20	1,74	24,79	0,62	130,18	3,27	109,00	223,42	5,61	
Y15-9W	4000-5000	58,15	1,45	20,37	0,51	140,65	3,51	102,32	219,17	5,47
Y16-10W		47,70	1,11	21,66	0,50	178,62	4,15	117,02	247,98	5,77
Y16-75W		51,98	1,17	24,87	0,56	185,05	4,16	90,63	260,43	5,85
Y16-76W		72,81	1,58	22,48	0,49	220,45	4,77	108,91	313,50	6,79
Y16-77W		77,94	1,68	23,37	0,50	203,08	4,37	108,99	299,67	6,44
Y16-78W		58,27	1,36	9,34	0,22	206,93	4,82	96,68	272,41	6,35
Y16-79W		79,49	1,79	25,87	0,58	156,87	3,53	113,10	260,49	5,87
Y15-81W		65,10	1,56	10,39	0,25	189,13	4,55	97,78	268,90	6,46
Y17-83W		74,89	1,44	25,98	0,50	197,83	3,80	118,82	296,74	5,71
Y15-84W		62,57	1,50	10,16	0,24	132,60	3,19	112,37	203,51	4,89
Y15-85W		64,05	1,58	7,86	0,19	203,78	5,02	96,67	276,19	6,80
Y16-102W		64,85	1,53	9,42	0,22	221,18	5,20	97,31	294,78	6,94

BIOLOGICAL MEASUREMENTS

Table VII. Red Seabream - organs weight and organs index

Fish code	Size range, g	Liver weight, g	LSI	Gonads weight, g	GSI	Gut weight, g	% Gut	Gill, g	Total viscera, g	VSI	Visceral fat	% Visc. Fat	Fat index*
S10-1W	750-1500	7,02	0,86	4,40	0,54	18,40	2,24	11,89	65,97	8,05	34,55	4,21	3
S13-2W		9,38	0,79	3,23	0,27	20,39	1,73	15,03	62,59	5,30	29,93	2,54	2
S12-3W		8,07	0,75	5,40	0,50	28,10	2,60	11,36	65,01	6,02	23,76	2,20	2
S15-4W		10,43	0,75	2,29	0,16	23,11	1,66	16,08	85,03	6,12	49,34	3,55	2
S12-7W		11,60	1,05	7,49	0,67	23,17	2,09	15,56	101,72	9,16	59,08	5,32	3
S14-14W		10,80	0,81	3,31	0,25	26,93	2,02	15,14	131,74	9,91	91,54	6,88	4
S11-15W		7,14	0,74	3,57	0,37	20,45	2,13	15,11	55,10	5,74	24,28	2,53	2
S11-17W		8,47	0,86	3,11	0,32	19,30	1,97	13,80	65,45	6,68	34,86	3,56	2
S13-18W		9,38	0,78	7,39	0,62	26,03	2,17	15,74	93,06	7,76	50,49	4,21	3
S11-21W		7,62	0,75	5,01	0,50	20,67	2,05	11,50	110,79	10,97	77,96	7,72	4
S11-22W		10,23	1,01	6,47	0,64	24,46	2,42	11,65	102,31	10,13	61,86	6,12	4
S11-23W		8,26	0,85	2,50	0,26	22,70	2,34	10,42	102,12	10,53	68,66	7,08	4
S11-24W		8,41	0,85	2,32	0,23	26,88	2,72	11,14	93,12	9,41	55,81	5,64	3
S12-25W		8,11	0,76	9,87	0,92	30,31	2,83	12,57	86,11	8,05	38,62	3,61	2
S21-5W		1500-2000	15,31	0,78	10,27	0,52	36,32	1,85	23,23	161,79	8,25	100,18	5,11
S17-6W	10,98		0,67	6,66	0,41	33,94	2,07	20,62	111,21	6,78	60,14	3,67	2
S21-8W	15,52		0,79	10,77	0,55	38,09	1,93	24,76	142,40	7,23	78,65	3,99	2
S20-9W	14,62		0,77	7,03	0,37	34,42	1,81	22,70	111,72	5,88	56,00	2,95	2
S19-10W	13,38		0,74	11,80	0,65	34,46	1,90	23,35	132,38	7,31	73,53	4,06	3
S20-11W	15,57		0,82	10,66	0,56	26,40	1,40	26,46	127,97	6,77	76,19	4,03	3
S19-12W	12,89		0,73	9,54	0,54	37,26	2,12	22,74	129,49	7,36	70,15	3,99	2
S18-13W	11,46		0,66	4,38	0,25	38,73	2,24	21,00	101,67	5,88	47,27	2,73	2
S21-16W	12,77		0,62	3,46	0,17	34,50	1,67	24,82	141,32	6,86	91,10	4,42	3
S19-19W	14,96		0,81	12,56	0,68	44,59	2,42	23,88	121,53	6,60	45,52	2,47	2
S20-20W	13,10		0,69	10,53	0,56	37,53	1,99	24,31	135,90	7,19	75,08	3,97	2
S19-26W	11,70		0,65	9,28	0,51	34,85	1,93	20,70	140,43	7,76	94,60	5,23	3
S21-27W	13,86		0,71	3,96	0,20	42,46	2,17	21,10	180,56	9,21	121,03	6,18	4
S21-28W	15,04		0,73	14,00	0,68	30,15	1,46	22,50	187,88	9,08	128,20	6,19	4
S20-29W	12,40		0,64	10,73	0,56	29,20	1,51	21,11	198,34	10,28	146,45	7,59	4
S20-30W	13,81	0,73	10,38	0,55	38,77	2,06	20,47	183,20	9,74	120,80	6,43	4	

* 1 = 0-2% , 2 = 2-4% , 3 = 4-6% , 4 = 6-8% , 5 = >8%

Table VIII. Amberjack - organs weight and organs index

Fish code	Size range, g	Liver weight, g	LSI	Gonads weight, g	GSI	Gut weight, g	% Gut	Gill, g	Total viscera, g	VSI
K11-1W	1350-2300	27,53	1,50	3,49	0,19	71,87	3,93	28,71	102,46	5,60
K10-2W		14,93	1,07	0,95	0,07	50,04	3,60	26,05	65,52	4,71
K11-3W		24,68	1,36	1,52	0,08	70,98	3,90	29,34	96,85	5,32
K10-4W		13,91	1,03	2,45	0,18	48,34	3,58	23,09	64,56	4,78
K10-5W		22,24	1,32	0,97	0,06	70,58	4,20	29,66	93,35	5,56
K11-6W		20,27	1,01	6,03	0,30	83,06	4,15	33,56	108,81	5,44
K11-7W		25,69	1,23	0,57	0,03	84,31	4,03	34,89	110,57	5,29
K12-8W		33,24	1,45	0,95	0,04	84,55	3,69	34,31	118,73	5,18
K10-9W		14,66	0,95	0,78	0,05	53,24	3,43	25,47	68,89	4,44
K10-10W		23,13	1,47	2,63	0,17	67,10	4,27	25,74	92,55	5,89
K10-11W		21,29	1,24	3,18	0,18	68,96	4,01	27,66	93,89	5,46
K10-12W		19,20	1,15	0,55	0,03	62,18	3,72	30,08	81,72	4,89
K10-13W		15,12	0,89	0,59	0,03	55,46	3,28	29,79	70,83	4,19
K11-14W		21,98	1,18	1,20	0,06	73,67	3,94	29,50	97,10	5,19
K10-15W		20,60	1,26	0,68	0,04	61,74	3,79	27,46	83,10	5,10
K10-16W		17,43	1,04	3,92	0,23	67,55	4,02	28,63	88,95	5,29
K11-17W		24,38	1,20	4,13	0,20	75,18	3,70	33,45	103,78	5,11
K10-18W		21,34	1,39	0,95	0,06	72,77	4,73	27,07	95,65	6,21
K11-19W		17,36	0,95	3,78	0,21	73,04	3,99	28,43	94,46	5,16

BIOLOGICAL MEASUREMENTS

Table IX. Seabream - organs weight and organs index

Fish code	Size range, g	Liver weight, g	LSI	Gonads weight, g	GSI	Gut weight, g	% Gut	Gill, g	Total viscera, g	VSI	Visceral fat, g	% Visc. Fat	Fat index*
D2-1	200	2,10	1,35	-	-	5,50	3,55	2,50	7,60	4,90	0,00	0,00	1
D2-2		2,70	1,42	1,10	0,58	6,30	3,32	2,80	10,10	5,33	0,00	0,00	1
D2-3		4,00	1,99	-	-	7,60	3,78	2,60	11,60	5,77	0,00	0,00	1
D2-4		4,20	1,92	6,50	2,98	5,40	2,47	2,90	16,10	7,38	0,00	0,00	1
D2-5		3,30	1,70	-	-	5,75	2,97	3,03	9,05	4,67	0,00	0,00	1
D2-6		3,57	1,77	-	-	6,78	3,36	3,19	12,73	6,30	2,38	1,18	1
D2-7		2,19	1,09	-	-	6,10	3,03	2,80	8,29	4,11	0,00	0,00	1
D2-8		3,28	1,44	0,29	0,13	7,39	3,24	3,76	12,04	5,28	1,08	0,47	1
D2-9		1,28	0,79	-	-	5,98	3,68	2,40	7,26	4,47	0,00	0,00	1
D2-10		4,91	2,56	-	-	7,44	3,88	2,84	12,35	6,44	0,00	0,00	1
D2-11		3,93	1,95	0,64	0,32	5,47	2,72	2,61	10,04	4,99	0,00	0,00	1
D2-12		2,14	1,25	-	-	6,53	3,80	2,67	8,67	5,05	0,00	0,00	1
D2-13		3,67	1,64	0,20	0,09	7,19	3,21	2,99	11,85	5,29	0,79	0,35	1
D2-14		1,46	0,86	0,48	0,28	6,15	3,64	3,15	8,09	4,79	0,00	0,00	1
D2-15		2,82	1,68	0,45	0,27	7,04	4,18	2,14	10,31	6,13	0,00	0,00	1
D3-1	300	4,80	1,57	10,10	3,29	7,70	2,51	4,40	22,60	7,37	0,00	0,00	1
D3-2		6,10	1,98	0,60	0,19	8,10	2,63	4,30	25,50	8,28	10,70	3,48	2
D3-3		7,60	2,53	1,70	0,57	7,80	2,60	3,80	19,30	6,43	2,20	0,73	1
D3-4		4,70	1,66	-	-	9,50	3,36	3,50	17,40	6,16	3,20	1,13	1
D3-5		5,44	1,72	0,54	0,17	7,72	2,44	4,16	15,20	4,81	1,50	0,47	1
D3-6		6,12	2,00	1,62	0,53	7,83	2,56	2,96	18,79	6,14	3,22	1,05	1
D3-7		6,06	2,17	3,43	1,23	7,69	2,75	4,30	18,20	6,52	1,02	0,37	1
D3-8		5,14	1,80	0,61	0,21	8,64	3,02	3,86	20,08	7,03	5,69	1,99	1
D3-9		7,46	2,77	0,94	0,35	7,95	2,95	3,01	18,38	6,81	2,03	0,75	1
D3-10		6,30	2,00	4,54	1,44	7,79	2,48	4,59	19,77	6,28	1,14	0,36	1
D3-11		6,24	2,06	1,98	0,65	8,73	2,88	3,80	16,95	5,60	0,00	0,00	1
D3-12		4,44	1,56	0,48	0,17	8,07	2,84	3,53	15,59	5,48	2,60	0,91	1
D3-13		-	-	-	-	-	-	4,10	-	-	-	-	-
D3-14		4,82	1,65	0,62	0,21	8,16	2,79	3,87	15,93	5,46	2,33	0,80	1
D3-15		7,24	2,27	1,46	0,46	6,25	1,96	4,03	18,51	5,80	3,56	1,12	1
D4-1	400	6,60	1,62	3,70	0,91	10,30	2,53	5,50	20,60	5,07	0,00	0,00	1
D4-2		9,10	2,24	8,40	2,07	9,30	2,29	4,70	33,60	8,27	6,80	1,67	1
D4-3		9,90	2,51	0,50	0,13	12,40	3,15	5,20	25,80	6,55	3,00	0,76	1
D4-4		9,20	2,48	0,80	0,22	9,20	2,48	4,50	22,70	6,12	3,50	0,94	1
D4-5		8,68	2,15	4,14	1,03	9,03	2,24	5,11	24,27	6,01	2,42	0,60	1
D4-6		7,67	1,97	-	-	11,45	2,94	5,32	23,40	6,01	4,28	1,10	1
D4-7		5,90	1,40	7,22	1,72	9,06	2,16	4,91	22,18	5,28	0,00	0,00	1
D4-8		7,19	2,05	0,58	0,17	9,44	2,69	4,56	20,36	5,80	3,15	0,90	1
D4-9		8,14	1,96	7,99	1,90	11,48	2,77	3,83	31,70	7,64	4,19	1,01	1
D4-10		11,62	2,90	0,72	0,18	9,98	2,49	4,98	32,01	7,99	9,69	2,42	2
D4-11		9,11	2,28	0,81	0,20	11,42	2,86	6,28	28,23	7,08	6,89	1,73	1
D4-12		10,47	2,72	1,15	0,30	10,03	2,61	4,66	29,78	7,74	8,13	2,11	2
D4-13		10,21	2,54	2,19	0,54	10,48	2,61	5,32	24,45	6,08	1,57	0,39	1
D4-14		7,69	2,10	5,24	1,43	8,44	2,31	4,66	28,56	7,81	7,19	1,97	1
D4-15		7,06	1,76	10,42	2,60	9,87	2,46	4,88	29,33	7,32	1,98	0,49	1
D5-1	500	8,60	1,80	9,00	1,89	14,80	3,10	6,10	39,30	8,24	6,90	1,45	1
D5-2		10,40	2,10	4,00	0,81	16,20	3,27	5,80	37,90	7,65	7,30	1,47	1
D5-3		12,90	2,53	16,40	3,22	13,60	2,67	6,00	49,30	9,68	6,40	1,26	1
D5-4		9,00	1,99	1,80	0,40	10,80	2,38	5,90	24,00	5,30	2,40	0,53	1
D5-5		7,82	1,69	1,31	0,28	11,41	2,47	6,35	25,76	5,58	5,22	1,13	1
D5-6		6,54	1,36	3,76	0,78	12,02	2,51	5,47	28,81	6,01	6,49	1,35	1
D5-7		8,23	1,77	5,68	1,22	12,53	2,70	5,50	34,12	7,36	7,68	1,66	1
D5-8		10,83	2,30	2,04	0,43	14,45	3,07	5,06	42,55	9,03	15,23	3,23	2
D5-9		9,26	2,03	17,85	3,92	12,22	2,69	4,56	44,64	9,81	5,31	1,17	1
D5-10		11,72	2,49	11,05	2,34	9,70	2,06	5,15	42,25	8,96	9,78	2,08	2
D5-11		7,69	1,62	10,55	2,22	12,93	2,73	5,08	34,55	7,28	3,38	0,71	1
D5-12		12,51	2,58	3,54	0,73	11,17	2,30	5,75	34,87	7,19	7,65	1,58	1
D5-13		9,28	1,99	5,36	1,15	11,10	2,38	5,68	37,05	7,95	11,31	2,43	2
D5-14		5,91	1,29	13,63	2,98	9,62	2,11	6,12	32,22	7,05	3,06	0,67	1
D5-15		9,25	2,03	11,07	2,43	9,36	2,05	5,59	38,53	8,46	8,85	1,94	1

* 1 = 0-2%, 2 = 2-4%, 3 = 4-6%, 4 = 6-8%, 5 = >8%

BIOLOGICAL MEASUREMENTS

Table Xa. Seabass - organs weight and organs index

Fish code	Size range, g	Liver weight, g	LSI	Gonads weight, g	GSI	Gut weight, g	% Gut	Gill, g	Total viscera, g	VSI	Visceral fat, g	% Visc. Fat	Fat index*
R1-1	100	1,40	1,75	0,00	0,00	2,90	3,63	1,40	5,70	7,13	1,40	1,75	1
R1-2		1,40	1,55	0,00	0,00	3,20	3,53	1,70	4,60	5,08	0,00	0,00	1
R1-3		2,40	2,22	0,00	0,00	3,46	3,19	1,74	9,50	8,77	3,64	3,36	2
R1-4		1,96	1,93	0,00	0,00	3,10	3,06	1,68	8,12	8,02	3,06	3,02	2
R1-5		1,92	2,18	0,00	0,00	2,43	2,76	1,29	8,10	9,20	3,75	4,26	3
R1-6		2,26	2,18	0,00	0,00	3,21	3,09	1,44	10,26	9,87	4,79	4,61	3
R1-7		1,63	2,16	0,00	0,00	2,01	2,66	0,89	6,32	8,36	2,68	3,54	2
R1-8		1,58	1,53	0,00	0,00	4,84	4,70	1,84	6,42	6,23	0,00	0,00	1
R1-9		2,73	2,36	0,00	0,00	2,80	2,42	1,60	12,94	11,16	7,41	6,39	4
R1-10		1,66	1,66	0,00	0,00	2,48	2,48	1,42	10,84	10,85	6,70	6,71	4
R1-11		3,18	2,97	0,00	0,00	2,87	2,68	1,33	14,92	13,93	8,87	8,28	5
R1-12		1,29	1,42	0,00	0,00	2,76	3,03	1,53	5,74	6,31	1,69	1,86	1
R1-13		1,63	1,54	0,00	0,00	4,38	4,14	2,04	6,01	5,68	0,00	0,00	1
R1-14		1,31	1,34	0,00	0,00	2,90	2,97	1,75	7,06	7,22	2,85	2,91	2
R1-15		2,96	2,29	0,00	0,00	3,67	2,84	1,62	16,43	12,71	9,80	7,58	4
R2-1	200	5,99	3,11	0,16	0,08	4,36	2,26	2,63	21,12	10,97	10,61	5,51	3
R2-2		5,40	2,94	0,08	0,04	4,27	2,32	2,67	18,20	9,90	8,45	4,60	3
R2-3		5,56	3,09	1,01	0,56	5,07	2,81	2,38	22,41	12,44	10,77	5,98	3
R2-4		5,36	2,82	0,07	0,04	5,35	2,82	2,08	24,23	12,75	13,45	7,08	4
R2-5		3,32	1,73	0,79	0,41	4,90	2,55	3,35	18,20	9,48	9,19	4,79	3
R2-6		3,81	2,13	0,06	0,03	3,92	2,19	2,63	21,01	11,76	13,22	7,40	4
R2-7		7,22	3,54	1,20	0,59	4,16	2,04	2,83	19,05	9,34	6,47	3,17	2
R2-8		4,08	2,19	0,12	0,06	4,37	2,34	2,68	20,08	10,76	11,51	6,17	4
R2-9		2,14	1,23	0,12	0,07	4,19	2,41	2,95	10,88	6,26	4,43	2,55	2
R2-10		4,28	2,32	0,13	0,07	3,96	2,15	2,43	25,61	13,90	17,24	9,36	5
R2-11		3,94	2,13	0,06	0,03	4,79	2,59	2,73	24,03	13,01	15,24	8,25	5
R2-12		4,01	2,07	0,08	0,04	4,30	2,22	3,08	19,69	10,18	11,30	5,84	3
R2-13		3,48	2,02	0,03	0,02	4,43	2,58	2,68	19,00	11,05	11,06	6,43	4
R2-14		3,70	1,98	0,08	0,04	5,17	2,77	3,11	16,12	8,64	7,17	3,84	2
R2-15		2,96	1,48	0,06	0,03	5,65	2,83	4,40	10,78	5,41	2,11	1,06	1
R3-1	300	6,00	2,03	0,17	0,06	7,08	2,40	3,17	35,94	12,16	22,69	7,68	4
R3-2		7,67	2,64	0,06	0,02	6,02	2,07	4,26	30,31	10,42	16,56	5,69	3
R3-3		7,67	2,67	0,60	0,21	6,27	2,18	3,95	31,51	10,97	16,97	5,91	3
R3-4		5,81	2,09	-	-	6,94	2,49	3,68	25,62	9,21	12,87	4,63	3
R3-5		7,62	2,39	0,22	0,07	5,40	1,69	3,85	40,70	12,75	27,46	8,60	5
R3-6		4,89	1,59	0,14	0,05	6,11	1,99	4,74	31,14	10,14	20,00	6,51	4
R3-7		6,75	2,30	0,27	0,09	5,73	1,95	4,52	35,55	12,12	22,80	7,78	4
R3-8		4,91	1,62	0,21	0,07	7,28	2,40	4,94	29,14	9,62	16,74	5,52	3
R3-9		6,49	2,10	0,22	0,07	5,83	1,89	4,31	48,91	15,83	36,37	11,77	5
R3-10		5,37	1,75	1,42	0,46	6,72	2,19	4,37	33,98	11,08	20,47	6,67	4
R3-11		5,86	2,09	0,11	0,04	6,18	2,20	4,20	30,58	10,91	18,43	6,57	4
R3-12		8,21	2,56	0,14	0,04	7,26	2,26	3,86	40,13	12,51	24,52	7,64	4
R3-13		8,36	2,94	0,33	0,12	6,73	2,37	3,77	29,87	10,50	14,45	5,08	3
R3-14		4,94	1,68	0,33	0,11	4,75	1,62	3,97	31,80	10,84	21,78	7,43	4
R3-15		4,40	1,65	0,19	0,07	7,08	2,65	4,51	29,13	10,89	17,46	6,53	4

* 1 = 0-2% , 2 = 2-4% , 3 = 4-6% , 4 = 6-8% , 5 = >8%

BIOLOGICAL MEASUREMENTS

Table Xb. Seabass - organs weight and organs index

Fish code	Size range, g	Liver weight, g	LSI	Gonads weight, g	GSI	Gut weight,g	% Gut	Gill,g	Total viscera, g	VSI	Visceral fat, g	% Visc. Fat	Fat index*
R4-1	400	8,51	2,33	0,69	0,19	7,88	2,16	4,61	44,49	12,18	27,41	7,51	4
R4-2		9,71	2,53	0,44	0,11	7,64	1,99	5,26	47,28	12,34	29,49	7,70	4
R4-3		9,21	2,28	1,88	0,47	8,72	2,16	5,40	44,43	11,00	24,62	6,10	4
R4-4		10,39	2,61	0,43	0,11	9,24	2,32	4,87	63,17	15,88	43,11	10,83	5
R4-5		8,99	2,45	0,42	0,11	9,34	2,54	4,94	54,76	14,91	36,01	9,81	5
R4-6		7,33	1,95	0,51	0,14	6,92	1,84	4,82	45,53	12,09	30,77	8,17	5
R4-7		6,57	1,69	0,41	0,11	7,33	1,89	5,19	57,58	14,82	43,27	11,14	5
R4-8		6,89	1,78	1,64	0,42	8,74	2,26	5,20	38,85	10,04	21,58	5,57	3
R4-9		10,31	2,48	0,63	0,15	10,28	2,48	5,55	51,02	12,29	29,80	7,18	4
R4-10		9,70	2,38	0,34	0,08	8,48	2,08	5,53	56,93	13,97	38,41	9,43	5
R4-11		9,99	2,56	0,23	0,06	8,36	2,15	6,21	47,97	12,32	29,39	7,55	4
R4-12		8,88	2,25	0,40	0,10	8,52	2,16	6,02	47,26	11,98	29,46	7,47	4
R4-13		8,37	2,10	1,27	0,32	7,74	1,94	5,55	56,54	14,19	39,16	9,83	5
R4-14		7,94	2,08	1,58	0,41	7,94	2,08	5,89	40,16	10,51	22,70	5,94	3
R4-15		7,44	1,98	1,75	0,47	8,39	2,23	5,41	35,90	9,56	18,32	4,88	3
R5-1	500	9,75	2,04	0,18	0,04	8,99	1,88	6,83	50,67	10,59	31,75	6,64	4
R5-2		6,74	1,43	1,04	0,22	8,74	1,86	6,82	56,76	12,08	40,24	8,56	5
R5-3		11,02	2,20	2,48	0,50	11,38	2,27	5,72	72,50	14,48	47,62	9,51	5
R5-4		10,83	2,30	2,26	0,48	9,95	2,12	5,63	50,16	10,67	27,12	5,77	3
R5-5		11,13	2,34	1,92	0,40	10,11	2,12	6,13	63,32	13,30	40,16	8,44	5
R5-6		9,94	2,11	1,93	0,41	11,13	2,36	6,00	55,97	11,86	32,97	6,98	4
R5-7		7,78	1,65	0,64	0,14	10,74	2,28	6,13	57,14	12,12	37,98	8,06	5
R5-8		12,83	2,53	0,23	0,05	9,35	1,84	6,54	63,87	12,60	41,46	8,18	5
R5-9		9,13	1,92	2,13	0,45	9,49	1,99	6,35	48,93	10,26	28,18	5,91	3
R5-10		10,39	2,04	2,95	0,58	10,93	2,14	7,41	64,55	12,66	40,28	7,90	4
R5-11		8,19	1,63	2,12	0,42	11,15	2,22	7,69	49,65	9,90	28,19	5,62	3
R5-12		12,32	2,53	2,05	0,42	8,84	1,82	7,21	56,90	11,70	33,69	6,93	4
R5-13		13,43	2,55	2,73	0,52	9,22	1,75	7,66	61,85	11,77	36,47	6,94	4
R5-14		8,95	1,86	2,11	0,44	8,45	1,76	7,60	47,01	9,80	27,50	5,73	3
R5-15		7,89	1,68	2,91	0,62	8,82	1,88	6,72	53,13	11,34	33,51	7,15	4

* 1 = 0-2% , 2 = 2-4% , 3 = 4-6% , 4 = 6-8% , 5 = >8%

CRUDE COMPOSITION

Table XIa. Yellowtail - body composition (moisture and protein)

Fish code	Size range, g	Fillet weight, g	Rest weight, g	% Moisture Fillet	% Moisture Rest	% Moisture whole fish	% Protein Fillet	% Protein Rest	% Protein whole fish
Y10-1W	1000-2000	305,0	745,0	73,2	72,2	72,5	21,0	19,4	19,9
Y10-2W		375,0	955,0	73,9	71,7	72,3	20,8	19,8	20,1
Y9-57W		285,0	705,0	74,7	74,5	74,6	22,6	20,3	21,0
Y10-58W		425,0	1015,0	73,1	70,2	71,1	22,8	20,3	21,0
Y10-59W		430,0	1030,0	72,9	70,4	71,1	21,7	20,4	20,8
Y10-65W		414,0	1038,4	74,4	73,4	73,7	21,7	19,6	20,2
Y9-66W		299,0	798,2	75,2	73,9	74,3	22,0	19,0	19,8
Y10-67W		392,0	978,5	71,4	71,1	71,2	21,7	19,2	19,9
Y9-68W		311,0	843,0	74,3	73,4	73,6	21,6	19,3	19,9
Y10-70W		364,0	956,0	74,4	73,0	73,4	22,5	20,2	20,8
Y11-86W		520,0	1260,0	64,3	63,7	63,9	20,3	18,8	19,2
Y11-94W		550,0	1340,0	67,2	65,1	65,7	20,4	18,3	18,9
Y11-95W		590,0	1380,0	65,9	64,6	65,0	20,7	18,3	19,0
Y11-101W		560,0	1370,0	67,5	65,8	66,3	20,8	18,6	19,2
Y13-60W	2000-3000	890,0	2015,0	67,7	65,5	66,2	22,8	20,1	20,9
Y13-62W		795,0	2010,0	70,4	66,6	67,7	22,3	20,2	20,8
Y13-63W		878,0	2056,0	71,4	68,2	69,2	21,5	19,0	19,7
Y11-87W		600,0	1450,0	64,3	63,3	63,6	20,7	18,7	19,3
Y12-88W		700,0	1550,0	64,9	62,5	63,2	20,3	18,7	19,2
Y11-89W		610,0	1450,0	66,2	63,4	64,2	21,0	19,2	19,7
Y11-90W		630,0	1450,0	68,3	65,2	66,1	21,2	19,2	19,8
Y11-91W		630,0	1480,0	65,6	63,8	64,3	20,7	19,0	19,5
Y11-92W		610,0	1450,0	65,6	64,8	65,0	21,1	18,6	19,3
Y12-93W		660,0	1590,0	68,5	66,9	67,4	21,2	19,0	19,6
Y12-96W		730,0	1650,0	63,6	62,5	62,8	20,5	18,2	18,9
Y12-97W		700,0	1620,0	65,5	63,9	64,4	20,7	18,5	19,2
Y12-98W		700,0	1700,0	65,0	63,8	64,2	20,9	19,0	19,6
Y12-99W		665,0	1570,0	65,8	64,2	64,7	20,7	18,7	19,3
Y12-100W		670,0	1590,0	66,1	65,1	65,4	20,6	18,2	18,9
Y13-3W	3000-4000	910,0	2155,0	70,7	67,3	68,3	21,2	19,6	20,1
Y13-4W		945,0	2230,0	69,8	68,2	68,7	21,5	19,7	20,2
Y13-5W		970,0	2395,0	67,5	66,1	66,5	22,1	19,9	20,5
Y13-6W		1065,0	2505,0	70,6	67,6	68,5	20,8	18,9	19,5
Y14-7W		1045,0	2405,0	63,5	61,8	62,3	20,8	19,0	19,5
Y13-8W		820,0	2200,0	62,9	62,0	62,2	20,8	19,3	19,7
Y14-11W		990,0	2380,0	64,0	62,6	63,0	21,2	19,4	19,9
Y13-61W		920,0	2155,0	71,8	68,5	69,5	22,3	20,2	20,8
Y14-64W		1029,0	2475,0	66,1	64,7	65,1	21,0	19,2	19,7
Y14-69W		1001,0	2243,0	68,3	65,2	66,2	21,4	19,1	19,8
Y14-71W		958,0	2298,0	68,2	65,4	66,2	21,4	19,9	20,3
Y14-72W		1030,0	2460,0	63,8	62,8	63,1	20,4	19,0	19,4
Y14-73W		1010,0	2450,0	67,3	64,7	65,5	19,8	18,0	18,5
Y15-74W		1060,0	2570,0	65,9	65,5	65,6	20,3	18,4	19,0
Y15-80W		1140,0	2710,0	65,2	63,7	64,1	19,2	17,6	18,1
Y15-82W		1050,0	2720,0	69,8	67,6	68,2	19,8	18,0	18,5
Y15-9W	4000-5000	1085,0	2760,0	62,0	61,1	61,4	21,1	19,6	20,0
Y16-10W		1265,0	3000,0	63,1	62,2	62,5	20,3	18,7	19,2
Y16-75W		1360,0	2980,0	62,7	62,0	62,2	20,3	18,9	19,3
Y16-76W		1350,0	3100,0	63,7	63,3	63,4	20,2	18,4	18,9
Y16-77W		1290,0	3110,0	65,3	63,1	63,7	19,2	17,6	18,1
Y16-78W		1250,0	2930,0	62,1	60,5	61,0	20,6	18,6	19,2
Y16-79W		1220,0	3100,0	66,9	64,6	65,2	20,0	18,6	19,0
Y15-81W		1230,0	2870,0	63,8	62,3	62,8	20,1	18,5	19,0
Y17-83W		1510,0	3490,0	64,7	62,9	63,4	20,6	18,3	19,0
Y15-84W		1170,0	2840,0	68,2	66,2	66,8	20,8	18,6	19,2
Y15-85W		1180,0	2760,0	62,4	61,7	61,9	19,8	18,2	18,7
Y16-102W		1220,0	2970,0	63,3	62,1	62,4	19,8	17,7	18,3

CRUDE COMPOSITION

Table X1b. Yellowtail - body composition (fat and ash)

Fish code	Size range, g	Fillet weight, g	Rest weight, g	% Fat Fillet	% Fat Rest	% Fat whole fish	% Ash Fillet	% Ash Rest	% Ash whole fish	
Y10-1W	1000-2000	305,0	745,0	2,10	2,90	2,7	2,9	2,9	2,9	
Y10-2W		375,0	955,0	1,70	3,10	2,7	2,6	4,1	3,7	
Y9-57W		285,0	705,0	0,60	1,30	1,1	2,3	4,0	3,5	
Y10-58W		425,0	1015,0	2,40	5,20	4,4	2,0	4,4	3,7	
Y10-59W		430,0	1030,0	3,00	5,30	4,6	2,1	4,0	3,4	
Y10-65W		414,0	1038,4	1,40	2,50	2,2	2,1	3,5	3,1	
Y9-66W		299,0	798,2	0,60	2,20	1,8	1,5	4,0	3,3	
Y10-67W		392,0	978,5	4,30	5,10	4,9	2,5	3,9	3,5	
Y9-68W		311,0	843,0	1,40	2,70	2,3	1,9	4,0	3,4	
Y10-70W		364,0	956,0	0,60	2,50	2,0	2,0	3,9	3,4	
Y11-86W		520,0	1260,0	11,80	13,00	12,6	3,3	4,0	3,8	
Y11-94W		550,0	1340,0	10,30	12,10	11,6	1,7	4,0	3,3	
Y11-95W		590,0	1380,0	11,40	12,60	12,2	1,9	3,8	3,2	
Y11-101W		560,0	1370,0	9,30	11,10	10,6	2,0	3,8	3,3	
Y13-60W		2000-3000	890,0	2015,0	7,7	10,2	9,4	1,9	3,7	3,1
Y13-62W			795,0	2010,0	7,0	8,1	7,8	2,3	4,3	3,7
Y13-63W	878,0		2056,0	4,6	7,5	6,6	1,7	4,3	3,5	
Y11-87W	600,0		1450,0	12,1	13,8	13,3	2,4	3,7	3,3	
Y12-88W	700,0		1550,0	12,4	14,9	14,1	2,1	3,5	3,1	
Y11-89W	610,0		1450,0	10,4	12,7	12,0	1,9	3,8	3,2	
Y11-90W	630,0		1450,0	8,6	10,7	10,1	1,7	4,5	3,7	
Y11-91W	630,0		1480,0	11,4	12,7	12,3	1,9	4,0	3,4	
Y11-92W	610,0		1450,0	11,3	12,3	12,0	1,9	3,8	3,2	
Y12-93W	660,0		1590,0	8,3	10,1	9,6	1,7	3,5	3,0	
Y12-96W	730,0		1650,0	13,8	15,2	14,8	1,7	3,7	3,1	
Y12-97W	700,0		1620,0	11,5	13,5	12,9	1,8	3,5	3,0	
Y12-98W	700,0		1700,0	11,9	12,4	12,3	2,0	4,1	3,5	
Y12-99W	665,0		1570,0	11,5	12,8	12,4	1,5	3,6	3,0	
Y12-100W	670,0		1590,0	11,1	12,5	12,1	1,9	3,6	3,1	
Y13-3W	3000-4000		910,0	2155,0	5,1	7,7	6,9	3,9	4,0	4,0
Y13-4W		945,0	2230,0	5,9	7,5	7,0	1,8	3,5	3,0	
Y13-5W		970,0	2395,0	7,1	9,5	8,8	2,2	4,3	3,7	
Y13-6W		1065,0	2505,0	6,0	8,8	8,0	1,5	1,8	1,7	
Y14-7W		1045,0	2405,0	13,1	15,2	14,6	1,6	3,5	2,9	
Y13-8W		820,0	2200,0	13,9	14,1	14,0	1,7	3,8	3,2	
Y14-11W		990,0	2380,0	12,5	13,5	13,2	1,6	3,6	3,0	
Y13-61W		920,0	2155,0	3,8	6,9	6,0	2,0	4,1	3,5	
Y14-64W		1029,0	2475,0	10,0	11,6	11,1	2,2	3,6	3,2	
Y14-69W		1001,0	2243,0	8,1	11,3	10,3	1,6	3,4	2,8	
Y14-71W		958,0	2298,0	8,0	10,4	9,7	1,7	3,8	3,2	
Y14-72W		1030,0	2460,0	13,6	14,2	14,0	1,8	3,5	3,0	
Y14-73W		1010,0	2450,0	10,8	12,9	12,3	1,9	4,3	3,6	
Y15-74W		1060,0	2570,0	11,2	12,0	11,8	2,1	3,6	3,2	
Y15-80W		1140,0	2710,0	13,6	14,6	14,3	1,7	3,6	3,0	
Y15-82W		1050,0	2720,0	8,2	10,6	9,9	2,2	3,6	3,2	
Y15-9W	4000-5000	1085,0	2760,0	14,6	14,5	14,5	1,7	3,8	3,2	
Y16-10W		1265,0	3000,0	14,3	15,0	14,8	1,7	3,4	2,9	
Y16-75W		1360,0	2980,0	15,1	16,0	15,7	1,6	2,7	2,4	
Y16-76W		1350,0	3100,0	14,3	12,4	13,0	1,7	3,3	2,8	
Y16-77W		1290,0	3110,0	13,7	14,9	14,5	1,7	4,1	3,4	
Y16-78W		1250,0	2930,0	15,7	16,8	16,5	1,7	3,6	3,0	
Y16-79W		1220,0	3100,0	11,3	13,0	12,5	1,8	3,7	3,2	
Y15-81W		1230,0	2870,0	14,5	15,2	15,0	1,7	3,4	2,9	
Y17-83W		1510,0	3490,0	13,1	14,8	14,3	1,7	3,6	3,0	
Y15-84W		1170,0	2840,0	8,8	11,1	10,4	1,9	3,8	3,2	
Y15-85W		1180,0	2760,0	16,0	16,7	16,5	1,7	3,1	2,7	
Y16-102W		1220,0	2970,0	14,8	16,2	15,8	1,9	3,6	3,1	

CRUDE COMPOSITION

Table Xlla. Red Seabream - body composition (moisture and protein)

Fish code	Size range, g	Fillet weight, g	Rest weight, g	% Moisture Fillet	% Moisture Rest	% Moisture whole fish	% Protein Fillet	% Protein Rest	% Protein whole fish
S10-1W	750-1500	230,0	580,0	64,7	57,9	59,8	19,3	16,7	17,4
S13-2W		350,0	810,0	63,5	56,7	58,8	20,2	17,8	18,5
S12-3W		310,0	760,0	65,7	60,8	62,2	20,7	18,5	19,1
S15-4W		410,0	960,0	61,0	56,9	58,1	20,1	17,2	18,1
S12-7W		310,0	780,0	65,8	58,7	60,7	20,5	17,8	18,6
S14-14W		350,0	960,0	62,4	57,0	58,4	20,6	16,2	17,4
S11-15W		270,0	680,0	64,6	59,7	61,1	18,8	17,1	17,6
S11-17W		280,0	680,0	62,0	58,0	59,2	19,8	16,8	17,7
S13-18W		340,0	840,0	64,5	59,6	61,0	19,7	17,0	17,8
S11-21W		270,0	720,0	63,4	56,4	58,3	20,0	17,2	18,0
S11-22W		280,0	720,0	63,4	55,7	57,9	20,9	17,4	18,4
S11-23W		280,0	700,0	62,5	54,5	56,7	20,0	17,8	18,4
S11-24W		280,0	700,0	66,4	56,5	59,3	20,4	17,7	18,5
S12-25W		310,0	750,0	65,7	57,0	59,5	20,2	17,7	18,4
S21-5W		1500-2000	570,0	1380,0	63,6	56,6	58,6	20,6	17,5
S17-6W	470,0		1160,0	64,9	59,6	61,1	20,4	17,4	18,3
S21-8W	570,0		1370,0	63,8	58,1	59,8	20,6	17,5	18,4
S20-9W	560,0		1320,0	62,8	59,9	60,8	21,3	18,0	19,0
S19-10W	530,0		1260,0	61,8	57,6	58,8	20,7	17,2	18,2
S20-11W	560,0		1310,0	65,5	61,0	62,3	20,6	17,6	18,5
S19-12W	500,0		1240,0	63,7	59,6	60,8	20,5	17,3	18,2
S18-13W	510,0		1200,0	63,6	58,7	60,2	21,2	17,8	18,8
S21-16W	610,0		1430,0	64,1	57,7	59,6	20,5	17,7	18,5
S19-19W	510,0		1310,0	64,0	60,6	61,6	21,0	17,6	18,6
S20-20W	530,0		1350,0	60,8	57,8	58,6	20,4	17,6	18,4
S19-26W	510,0		1280,0	63,0	54,8	57,1	20,9	16,5	17,8
S21-27W	550,0		1390,0	59,2	53,1	54,8	19,7	16,4	17,3
S21-28W	570,0		1460,0	63,7	55,8	58,0	21,4	17,2	18,4
S20-29W	530,0		1390,0	62,8	52,8	55,6	20,1	16,3	17,3
S20-30W	500,0	1360,0	66,3	56,8	59,4	20,8	17,20	18,2	

Table Xllla. Amberjack - body composition (moisture and protein)

Fish code	Size range, g	Fillet weight, g	Rest weight, g	% Moisture Fillet	% Moisture Rest	% Moisture whole fish	% Protein Fillet	% Protein Rest	% Protein whole fish
K11-1W	1350-2300	560,0	1260,0	64,7	62,4	63,1	20,5	18,5	19,1
K10-2W		400,0	960,0	65,8	64,0	64,5	20,4	18,6	19,1
K11-3W		570,0	1230,0	62,4	61,1	61,5	19,3	18,7	18,9
K10-4W		390,0	940,0	65,4	65,3	65,3	21,0	18,7	19,4
K10-5W		520,0	1130,0	63,0	60,6	61,4	19,5	18,0	18,5
K11-6W		600,0	1370,0	64,7	62,7	63,3	20,8	19,1	19,6
K11-7W		630,0	1440,0	64,8	62,3	63,1	20,6	18,6	19,2
K12-8W		690,0	1570,0	63,8	61,9	62,5	20,4	19,0	19,4
K10-9W		470,0	1060,0	68,3	66,0	66,7	21,1	18,8	19,5
K10-10W		470,0	1080,0	63,2	61,7	62,2	20,3	18,5	19,0
K10-11W		530,0	1180,0	66,3	62,5	63,7	20,6	19,0	19,5
K10-12W		500,0	1150,0	68,2	65,0	66,0	20,1	18,6	19,1
K10-13W		510,0	1170,0	65,2	63,6	64,1	20,3	19,2	19,5
K11-14W		560,0	1290,0	65,0	62,7	63,4	20,3	18,9	19,3
K10-15W		480,0	1130,0	66,6	63,3	64,3	20,1	18,5	19,0
K10-16W		500,0	1160,0	67,1	64,5	65,3	20,5	19,1	19,5
K11-17W		610,0	1400,0	66,7	63,1	64,2	20,2	18,6	19,1
K10-18W		450,0	1070,0	66,7	64,5	65,2	19,9	18,4	18,8
K11-19W		560,0	1250,0	66,2	62,8	63,9	20,4	18,4	19,0

CRUDE COMPOSITION

Table XIIIb. Red Seabream - body composition (fat and ash)

Fish code	Size range, g	Fillet weight, g	Rest weight, g	% Fat Fillet	% Fat Rest	% Fat whole fish	% Ash Fillet	% Ash Rest	% Ash whole fish
S10-1W	750-1500	230,0	580,0	13,0	18,2	16,7	2,6	5,9	5,0
S13-2W		350,0	810,0	13,2	17,0	15,9	3,0	7,2	5,9
S12-3W		310,0	760,0	9,3	12,9	11,9	3,9	6,6	5,8
S15-4W		410,0	960,0	14,6	18,8	17,5	3,7	6,0	5,3
S12-7W		310,0	780,0	10,5	17,6	15,6	2,8	5,0	4,4
S14-14W		350,0	960,0	12,0	19,9	17,8	4,6	5,1	5,0
S11-15W		270,0	680,0	12,7	15,2	14,5	3,0	7,2	6,0
S11-17W		280,0	680,0	13,6	19,2	17,6	4,1	4,8	4,6
S13-18W		340,0	840,0	12,0	17,6	16,0	2,8	4,2	3,8
S11-21W		270,0	720,0	12,9	22,6	20,0	4,1	3,2	3,4
S11-22W		280,0	720,0	12,4	19,8	17,7	3,5	5,9	5,2
S11-23W		260,0	700,0	14,1	21,2	19,3	3,5	6,3	5,5
S11-24W		280,0	700,0	11,2	18,6	16,5	2,3	6,7	5,4
S12-25W		310,0	750,0	11,3	17,4	15,6	2,9	6,8	5,7
S21-5W		1500-2000	570,0	1380,0	11,9	18,3	16,4	3,5	6,2
S17-6W	470,0		1160,0	10,7	16,4	14,8	3,5	5,5	4,9
S21-8W	570,0		1370,0	11,8	17,4	15,8	3,3	6,3	5,4
S20-9W	560,0		1320,0	11,9	15,6	14,5	3,6	5,9	5,2
S19-10W	530,0		1260,0	13,5	19,6	17,8	3,5	5,0	4,6
S20-11W	560,0		1310,0	9,4	16,0	14,0	4,0	4,5	4,4
S19-12W	500,0		1240,0	11,6	16,0	14,7	3,6	5,9	5,2
S18-13W	510,0		1200,0	10,7	15,2	13,9	4,3	7,1	6,3
S21-16W	610,0		1430,0	11,9	18,2	16,3	2,8	5,4	4,6
S19-19W	510,0		1310,0	10,0	14,9	13,5	4,1	5,5	5,1
S20-20W	530,0		1350,0	13,1	17,3	16,1	5,0	5,7	5,5
S19-26W	510,0		1280,0	11,9	22,7	19,6	3,9	5,0	4,7
S21-27W	550,0		1390,0	17,7	12,2	13,8	2,8	5,2	4,5
S21-28W	570,0		1460,0	11,9	20,6	18,2	3,3	5,7	5,0
S20-29W	530,0		1390,0	14,1	24,4	21,6	3,1	5,5	4,8
S20-30W	500,0		1360,0	10,7	20,1	17,6	2,7	4,8	4,2

Table XIIIb. Amberjack - body composition (fat and ash)

Fish code	Size range, g	Fillet weight, g	Rest weight, g	% Fat Fillet	% Fat Rest	% Fat whole fish	% Ash Fillet	% Ash Rest	% Ash whole fish
K11-1W	1350-2300	560,0	1260,0	12,7	14,8	14,2	2,1	4,0	3,4
K10-2W		400,0	960,0	10,6	12,0	11,6	2,9	4,6	4,1
K11-3W		570,0	1230,0	15,2	16,2	15,9	2,3	3,7	3,3
K10-4W		390,0	940,0	10,9	11,7	11,5	2,4	3,9	3,5
K10-5W		520,0	1130,0	15,5	16,6	16,3	1,9	4,3	3,5
K11-6W		600,0	1370,0	12,0	13,5	13,0	2,1	4,3	3,6
K11-7W		630,0	1440,0	12,9	14,5	14,0	1,8	3,8	3,2
K12-8W		690,0	1570,0	13,6	14,6	14,3	2,0	4,0	3,4
K10-9W		470,0	1060,0	8,3	11,0	10,2	2,1	4,0	3,4
K10-10W		470,0	1080,0	14,0	15,3	14,9	2,2	4,1	3,5
K10-11W		530,0	1180,0	10,9	12,9	12,3	2,1	5,1	4,2
K10-12W		500,0	1150,0	9,4	11,5	10,9	1,9	4,1	3,4
K10-13W		510,0	1170,0	11,8	12,3	12,1	2,4	4,6	3,9
K11-14W		560,0	1290,0	12,5	14,0	13,5	2,2	4,1	3,5
K10-15W		480,0	1130,0	10,7	13,4	12,6	2,2	4,3	3,7
K10-16W		500,0	1160,0	10,2	12,1	11,5	2,1	4,2	3,6
K11-17W		610,0	1400,0	10,8	13,4	12,6	2,0	4,5	3,7
K10-18W		450,0	1070,0	11,2	12,5	12,1	1,9	3,8	3,2
K11-19W		560,0	1250,0	11,4	14,0	13,2	1,9	4,2	3,5

CRUDE COMPOSITION

Table XIV. Seabream - body composition

Fish code	Size range, g	Total weight, g	% Moisture	% Protein	% Fat	% Ash
D2-1	200	155,1	66,1	17,6	12,1	3,9
D2-2		189,5	64,6	17,3	14,0	4,1
D2-3		201,0	64,9	17,7	13,2	3,9
D2-4		218,3	64,2	17,5	14,3	4,0
D2-5		193,7	67,2	18,3	10,0	4,3
D2-6		202,0	64,6	17,5	13,5	4,3
D2-7		201,5	69,6	17,5	8,3	4,7
D2-8		227,9	67,5	18,1	10,3	4,1
D2-9		162,5	66,5	17,2	12,0	4,4
D2-10		191,9	72,0	17,1	5,7	4,8
D2-11		201,1	64,5	17,9	13,0	4,2
D2-12		171,7	66,3	17,5	11,5	4,6
D2-13		224,1	65,0	18,9	11,5	4,3
D2-14		168,9	65,3	17,9	12,9	4,0
D2-15		168,3	64,9	17,7	13,5	3,8
D3-1	300	306,7	65,6	18,2	12,5	3,4
D3-2		307,8	63,3	17,1	15,5	3,4
D3-3		300,2	64,9	17,8	15,1	4,1
D3-4		282,5	65,1	17,8	12,7	3,9
D3-5		316,0	62,5	18,2	14,6	4,4
D3-6		306,2	63,0	17,9	14,9	4,0
D3-7		279,2	65,0	18,0	12,6	4,2
D3-8		285,7	64,4	17,7	13,8	3,8
D3-9		269,8	63,1	18,3	15,1	3,8
D3-10		314,6	64,5	17,5	13,0	4,3
D3-11		302,7	63,7	17,9	13,9	4,0
D3-12		284,5	64,1	17,5	14,0	4,3
D3-13		294,4	66,8	17,3	11,6	4,4
D3-14		292,0	63,7	18,0	14,4	3,9
D3-15		318,9	61,6	17,7	16,6	3,8
D4-1	400	406,7	62,3	18,2	15,8	4,0
D4-2		406,4	62,6	18,8	15,9	3,7
D4-3		394,1	60,1	17,7	18,9	3,5
D4-4		370,7	61,2	17,6	16,8	3,9
D4-5		403,6	64,3	18,2	13,4	4,0
D4-6		389,2	61,6	18,1	16,1	4,0
D4-7		420,1	64,9	18,4	12,5	3,9
D4-8		351,0	62,6	17,4	16,4	3,7
D4-9		415,0	61,7	19,7	16,9	4,2
D4-10		400,4	60,2	18,0	18,0	4,1
D4-11		398,8	61,5	18,1	16,2	4,2
D4-12		385,0	60,6	17,7	17,9	3,5
D4-13		402,2	61,8	18,1	15,9	3,9
D4-14		365,9	63,8	17,9	14,3	3,8
D4-15		400,9	63,2	18,3	14,8	3,9
D5-1	500	476,7	61,3	17,6	16,8	3,8
D5-2		495,6	60,9	17,6	16,9	3,9
D5-3		509,5	62,3	17,8	15,6	3,9
D5-4		453,2	64,5	18,3	14,5	3,9
D5-5		461,7	63,3	18,8	14,1	3,8
D5-6		479,6	60,5	17,6	17,5	4,1
D5-7		463,7	61,5	17,5	16,7	4,0
D5-8		471,1	58,0	17,0	21,0	3,6
D5-9		455,1	62,1	17,7	16,5	3,8
D5-10		471,3	60,4	17,6	17,0	4,1
D5-11		474,3	61,1	17,8	16,7	4,1
D5-12		485,1	61,6	17,7	16,0	4,1
D5-13		466,3	63,30	17,6	15,7	3,1
D5-14		456,7	63,50	18,1	14,5	3,3
D5-15		455,6	62,10	17,6	15,9	3,8

CRUDE COMPOSITION

Table XV. Seabass - body composition

Fish code	Size range, g	Total weight, g	% Moisture	% Protein	% Fat	% Ash
R1-1	100	79,9	67,1	18,2	9,3	5,3
R1-2		90,6	69,4	18,6	7,1	4,8
R1-3		108,3	66,1	18,0	12,9	3,0
R1-4		101,3	67,5	18,6	9,1	5,1
R1-5		88,0	64,1	18,0	13,2	4,8
R1-6		103,9	66,2	18,3	12,2	4,5
R1-7		75,6	67,1	18,5	9,5	4,9
R1-8		103,0	68,2	18,4	8,6	4,7
R1-9		115,9	64,5	18,4	12,7	4,7
R1-10		99,9	63,7	18,3	13,6	4,5
R1-11		107,1	63,6	18,2	13,7	4,6
R1-12		91,0	69,0	18,3	7,9	4,7
R1-13		105,8	69,6	18,6	6,6	5,2
R1-14		97,8	68,1	19,0	8,2	5,0
R1-15		129,3	63,7	18,3	13,5	4,7
R2-1	200	192,5	61,9	18,0	16,2	4,1
R2-2		183,8	62,3	18,6	14,9	4,5
R2-3		180,2	59,4	17,8	19,4	3,9
R2-4		190,0	61,3	18,1	15,8	3,9
R2-5		192,0	66,2	18,4	11,9	3,7
R2-6		178,7	62,6	17,8	15,3	4,5
R2-7		203,9	62,0	18,8	16,0	4,1
R2-8		186,6	61,9	17,8	16,4	4,0
R2-9		173,9	66,1	18,7	11,0	4,3
R2-10		184,2	58,1	17,7	20,6	4,0
R2-11		184,7	61,6	18,4	16,8	4,1
R2-12		193,4	63,9	18,1	13,4	4,6
R2-13		172,0	62,6	18,4	14,5	4,5
R2-14		186,6	66,3	18,4	10,2	4,6
R2-15		199,4	68,6	18,2	7,8	5,0
R3-1	300	295,5	59,9	18,1	18,4	4,0
R3-2		290,9	60,1	18,4	17,6	4,1
R3-3		287,3	61,3	18,0	17,0	4,0
R3-4		278,2	62,1	18,2	15,8	3,9
R3-5		319,3	57,9	17,7	19,8	4,4
R3-6		307,0	61,7	18,6	15,6	4,1
R3-7		293,2	60,2	17,9	17,1	4,4
R3-8		303,0	63,0	18,2	14,3	4,1
R3-9		308,9	57,0	17,2	21,0	4,1
R3-10		306,8	59,7	18,3	18,3	4,3
R3-11		280,4	59,9	17,9	18,4	4,3
R3-12		320,8	61,8	17,8	16,8	3,5
R3-13		284,4	62,3	19,1	14,5	4,4
R3-14		293,3	58,0	18,1	20,0	3,8
R3-15		267,4	61,3	18,4	16,3	4,3
R4-1	400	365,2	58,3	17,9	19,6	4,1
R4-2		383,2	58,6	18,2	19,6	3,9
R4-3		403,9	58,8	17,9	19,5	4,2
R4-4		397,9	57,0	18,0	21,8	4,0
R4-5		367,2	58,1	18,4	18,7	4,4
R4-6		376,7	56,9	19,2	19,6	4,2
R4-7		388,4	55,8	19,5	22,1	4,0
R4-8		387,1	61,1	17,8	16,6	4,1
R4-9		415,2	60,2	18,3	17,9	3,9
R4-10		407,4	57,4	17,8	21,0	4,2
R4-11		389,5	59,2	18,0	19,1	4,2
R4-12		394,5	57,7	18,5	19,9	4,4
R4-13		398,4	55,5	17,5	23,3	3,8
R4-14		382,1	59,8	18,2	17,7	4,3
R4-15		375,5	61,3	18,8	15,9	4,1
R5-1	500	478,5	59,2	18,7	19,1	4,2
R5-2		469,9	58,0	19,4	18,8	4,0
R5-3		500,6	58,6	19,0	18,8	3,7
R5-4		470,1	59,4	18,7	18,1	3,9
R5-5		476,1	57,7	19,4	19,2	4,1
R5-6		472,1	57,9	18,6	19,8	3,9
R5-7		471,4	58,5	18,4	19,3	3,6
R5-8		506,9	57,5	18,3	19,9	4,0
R5-9		476,7	59,4	18,0	18,8	3,8
R5-10		510,0	57,9	17,5	19,2	4,4
R5-11		501,3	60,3	17,9	17,6	4,0
R5-12		486,4	58,4	18,1	19,9	4,0
R5-13		525,7	57,6	19,0	19,0	4,2
R5-14		479,9	60,6	18,6	17,0	3,9
R5-15		468,7	58,6	18,4	18,5	4,4

