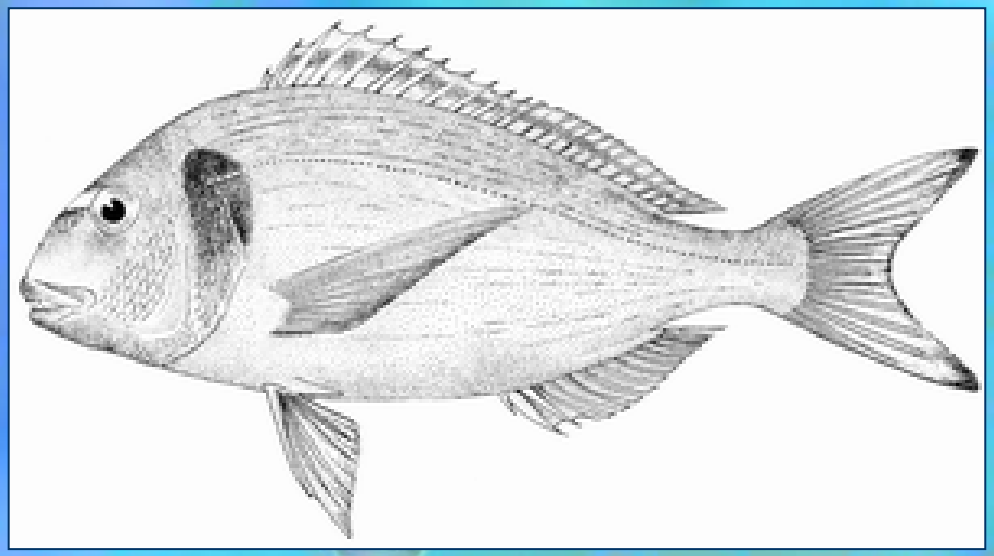
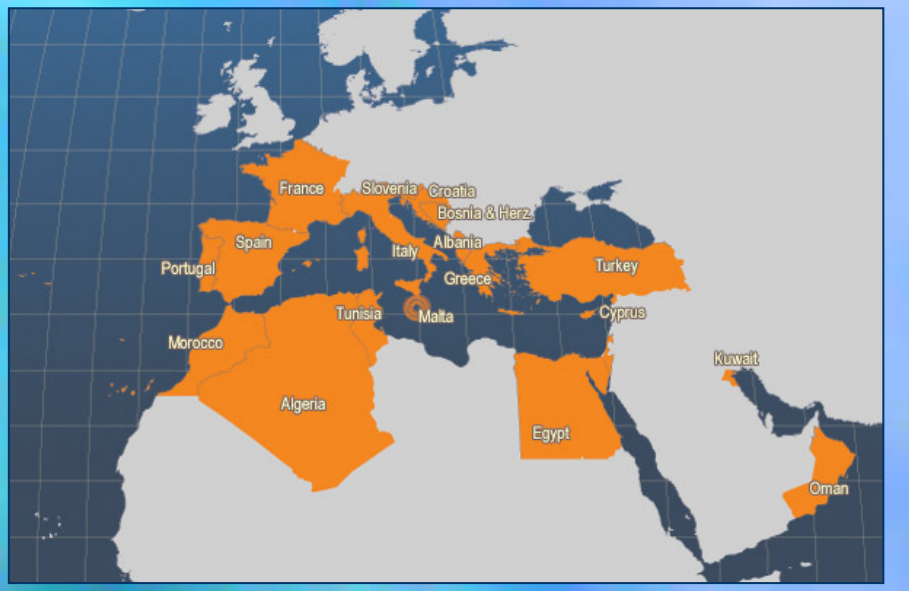
Raw materials and feed optimization for farming of seabass and bream

Fiskeriforskning

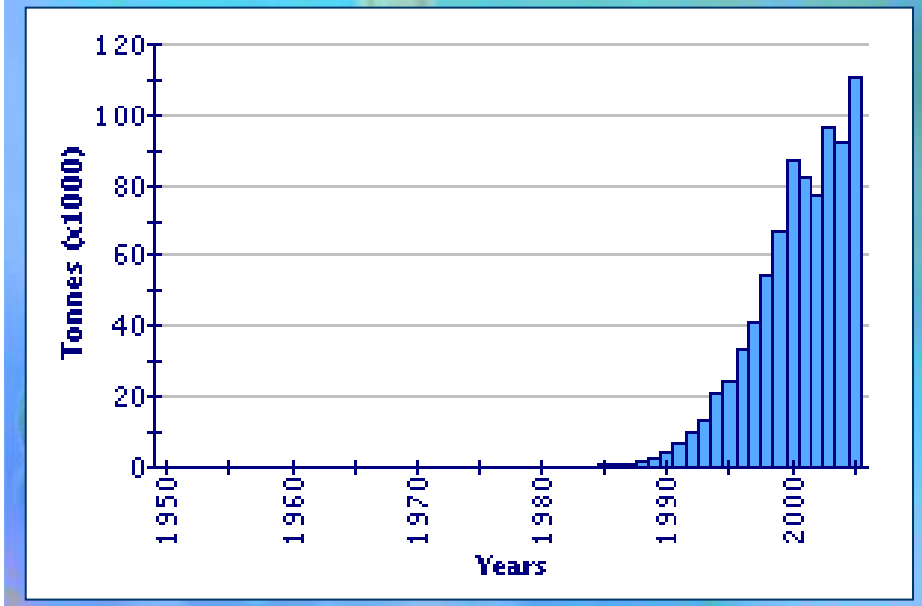
Katerina Kousoulaki

Gilthead seabream, *Sparus aurata* (Linnaeus, 1758)



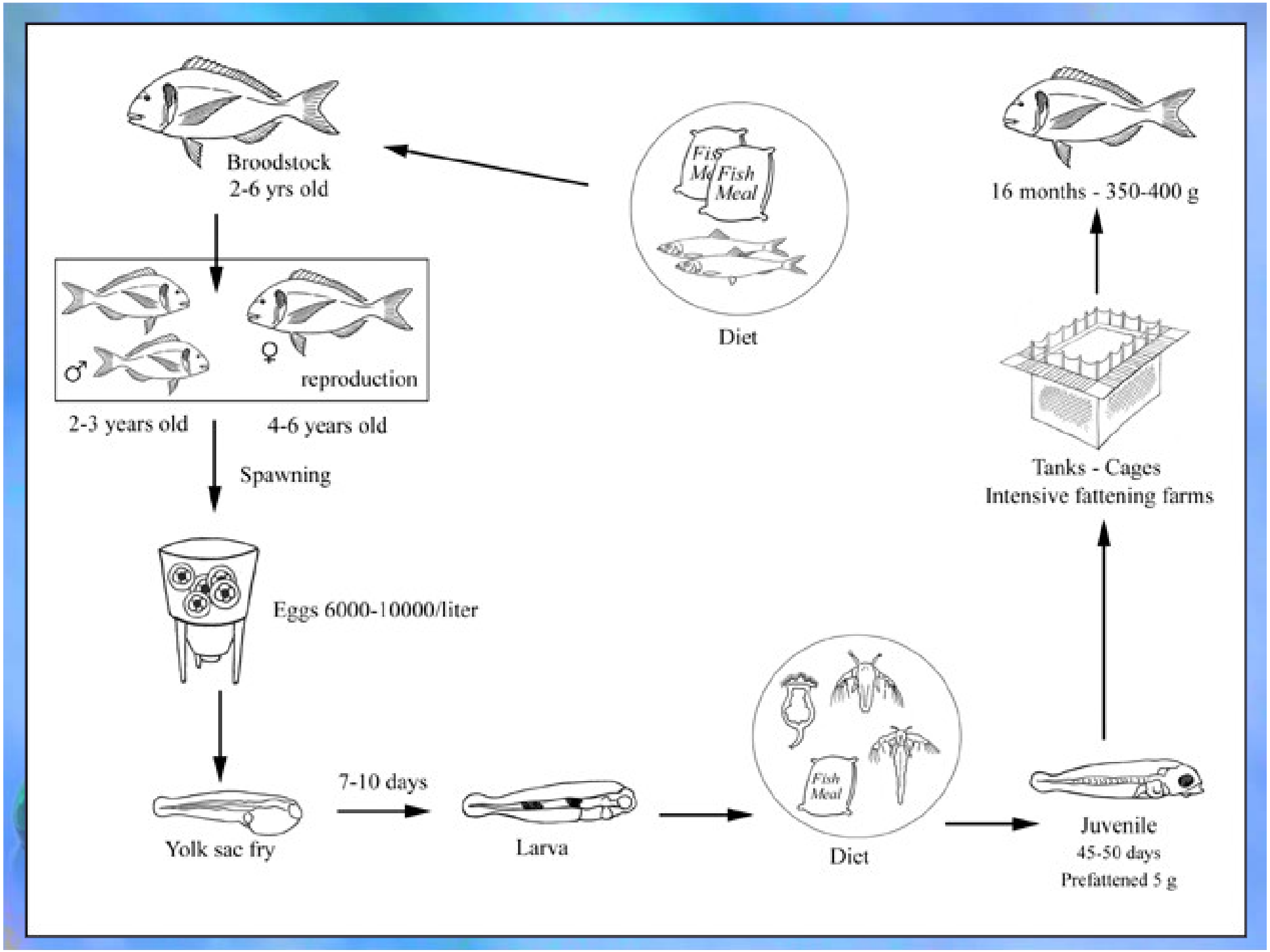


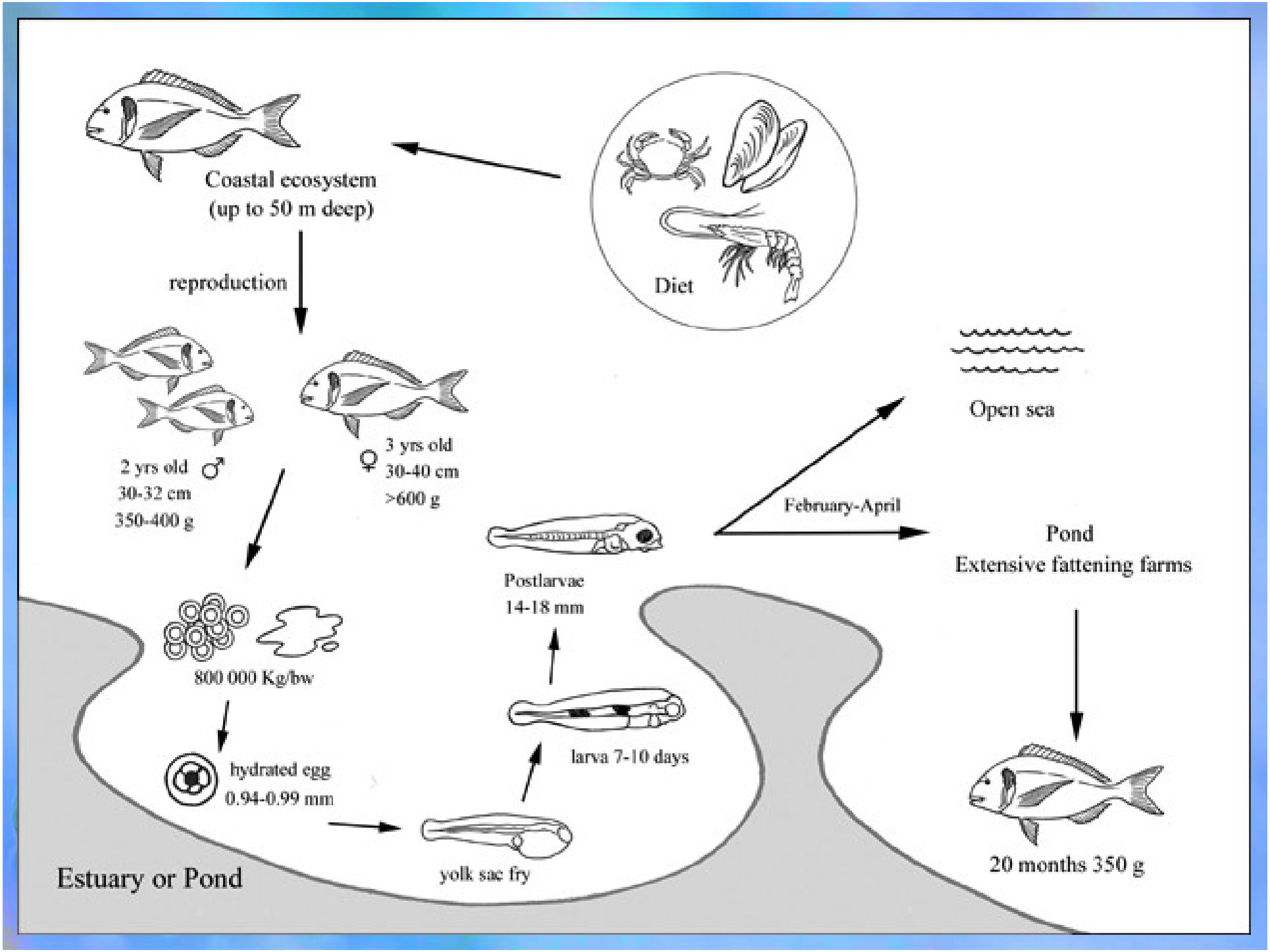
Main producer countries of Sparus aurata (FAO Fishery Statistics, 2002)



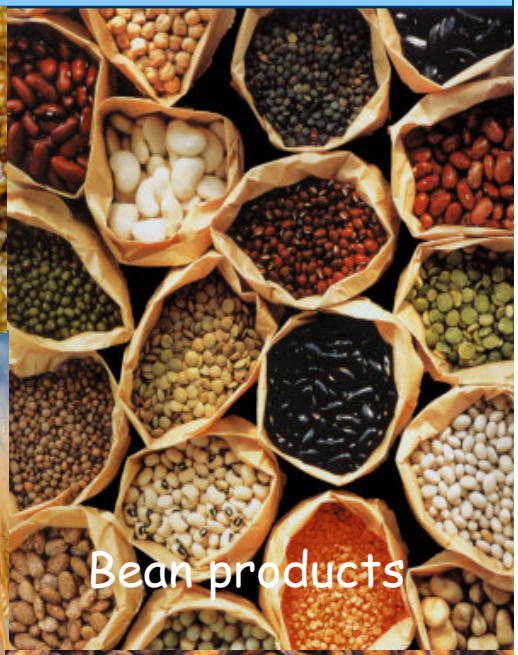
Global aquaculture production of *Sparus aurata*
(FAO Fishery Statistic)

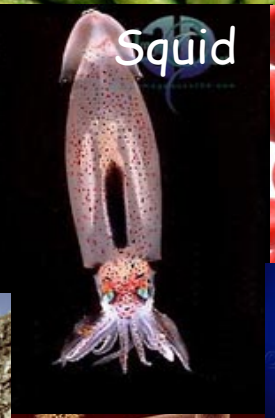
Fiskeriforskning


Broodstock
2-6 yrs old
Fish Meal
Diet
16 months - 350-400 g
♂
♀
reproduction
2-3 years old
4-6 years old
Spawning
Tanks - Cages
Intensive fattening farms
Eggs 6000-10000/liter
7-10 days
Yolk sac fry
Larva
Fish Meal
Diet
Juvenile
45-50 days
Prefattened 5 g


Coastal ecosystem
(up to 50 m deep)
Diet
reproduction
2 yrs old ♂
30-32 cm
350-400 g
♀ 3 yrs old
30-40 cm
>600 g
Open sea
February-April
Pond
Extensive fattening farms
Postlarvae
14-18 mm
800 000 Kg/bw
hydrated egg
0.94-0.99 mm
larva 7-10 days
yolk sac fry
Estuary or Pond
20 months 350 g

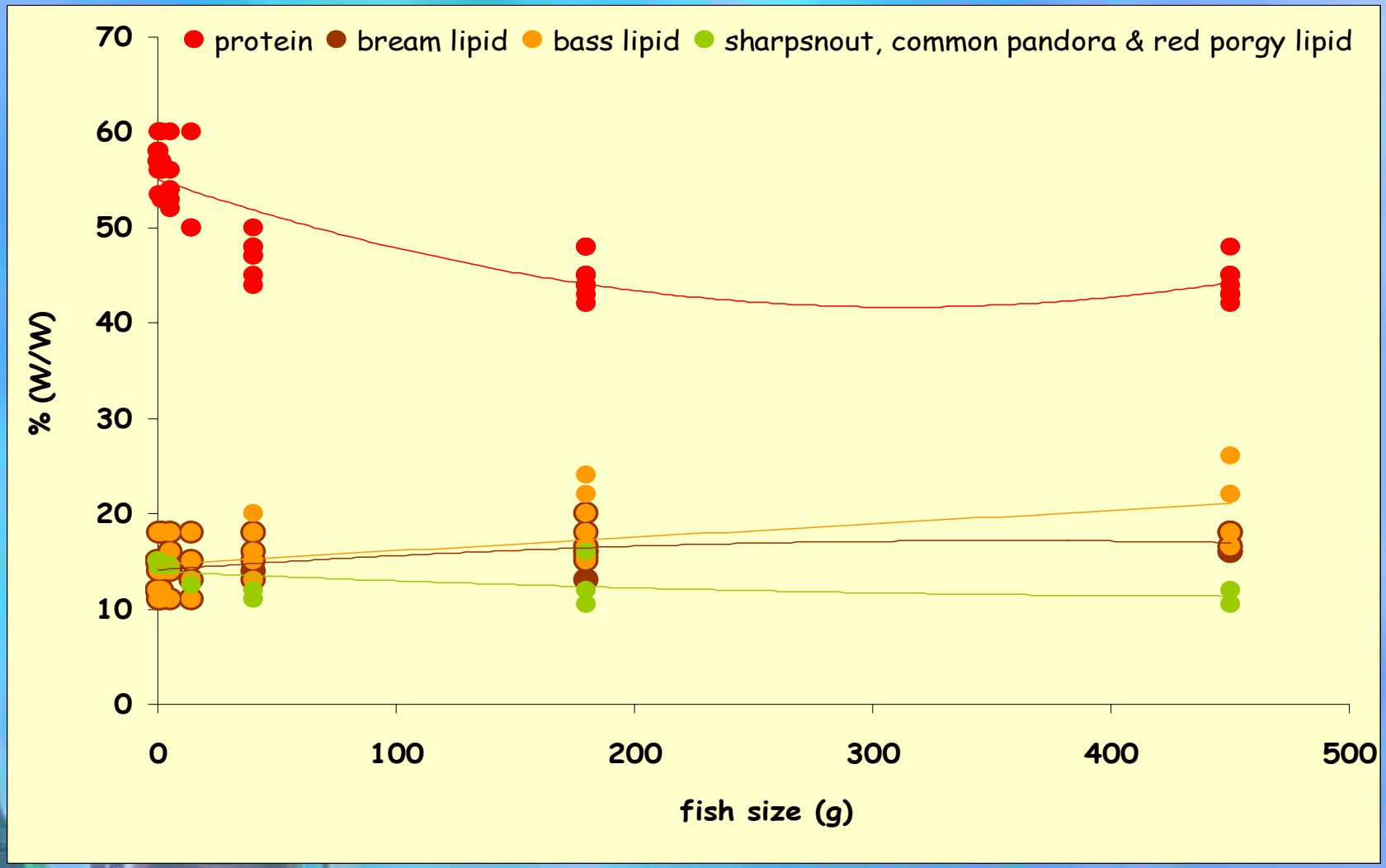
Raw materials in Gilthead seabream diets





Fiskeriforskning

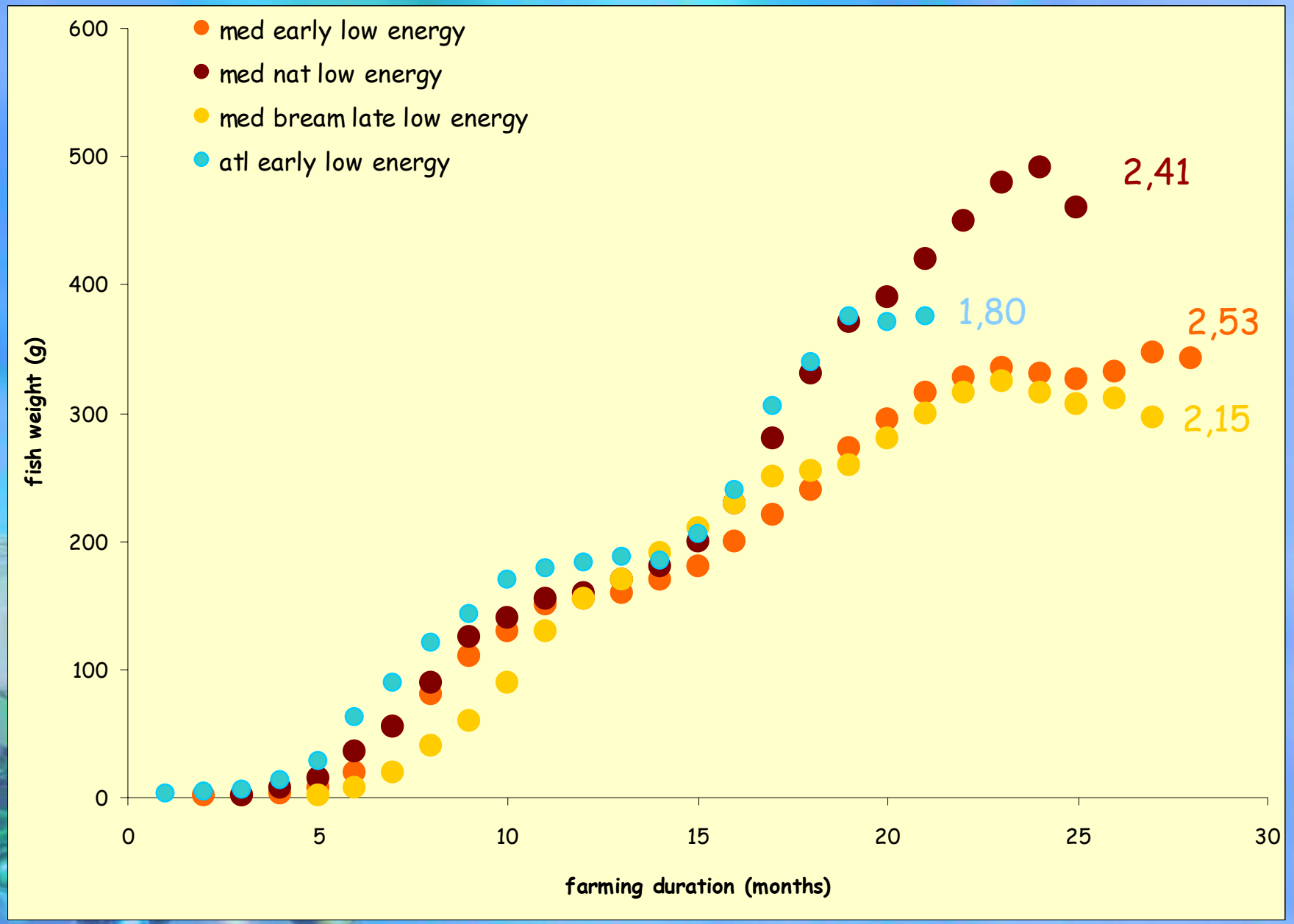
Commercial feeds protein & lipid levels for sea bass and bream



	protein	bream lipid	bass lipid	sharpsnout, common pandora & red porgy lipid
level in feed (%)	42-60	10,5-20	11-26	10,5-16

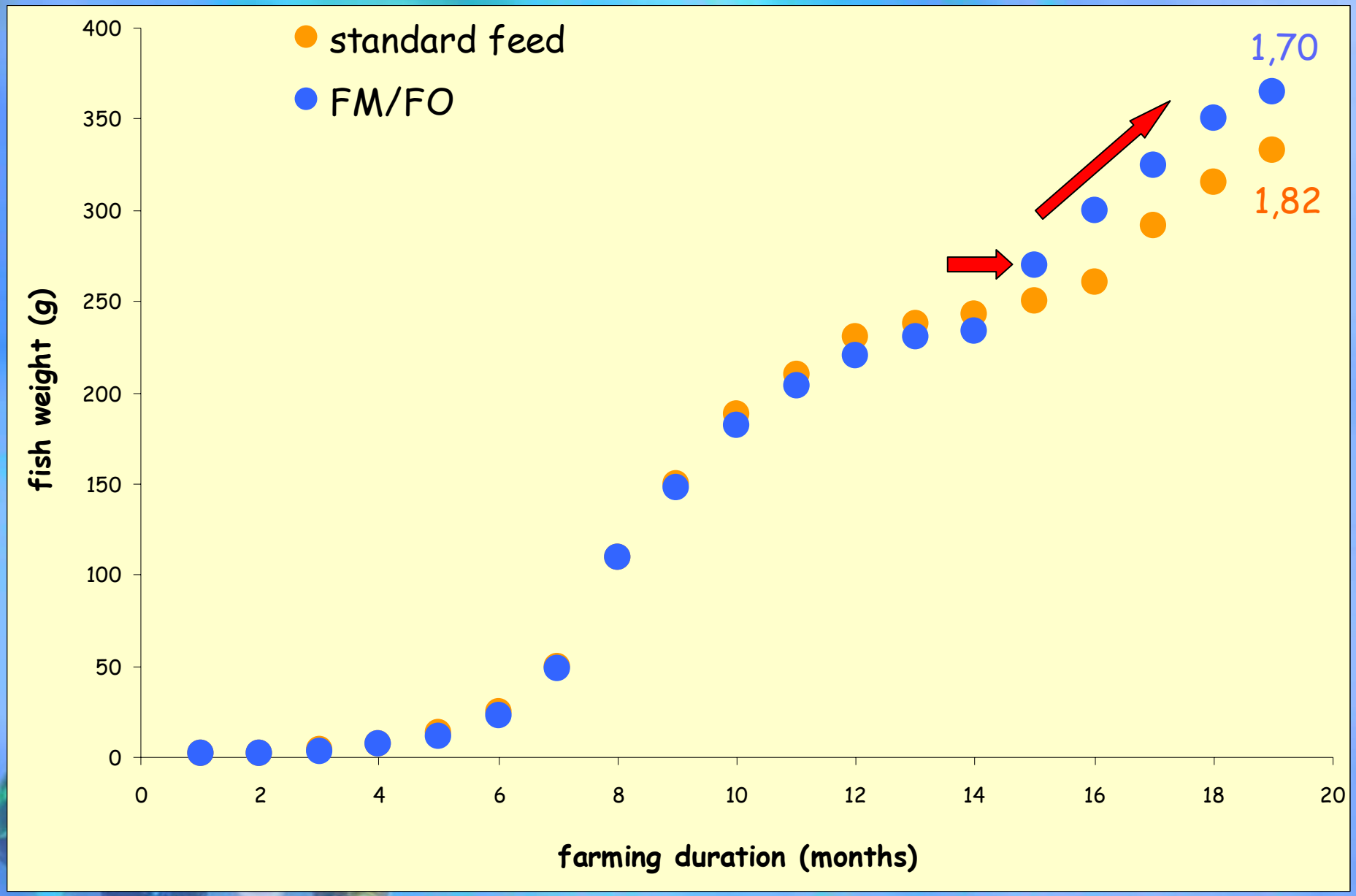
Fiskeriforskning

Sea bream on-growing production results from Greece



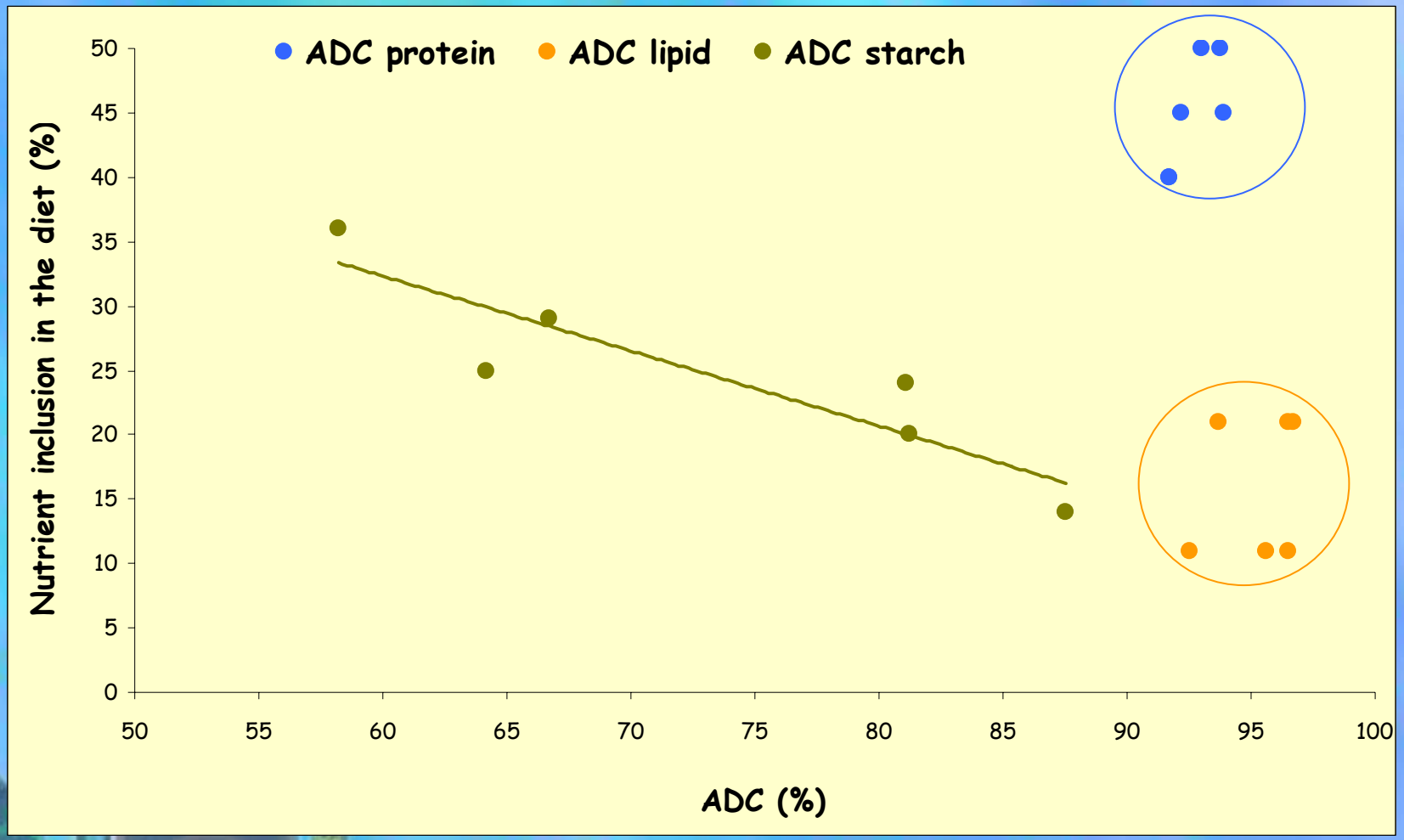
Fiskeriforskning

Sea bream on-growing -commercial data- Marine vs V protein



Fiskeriforskning

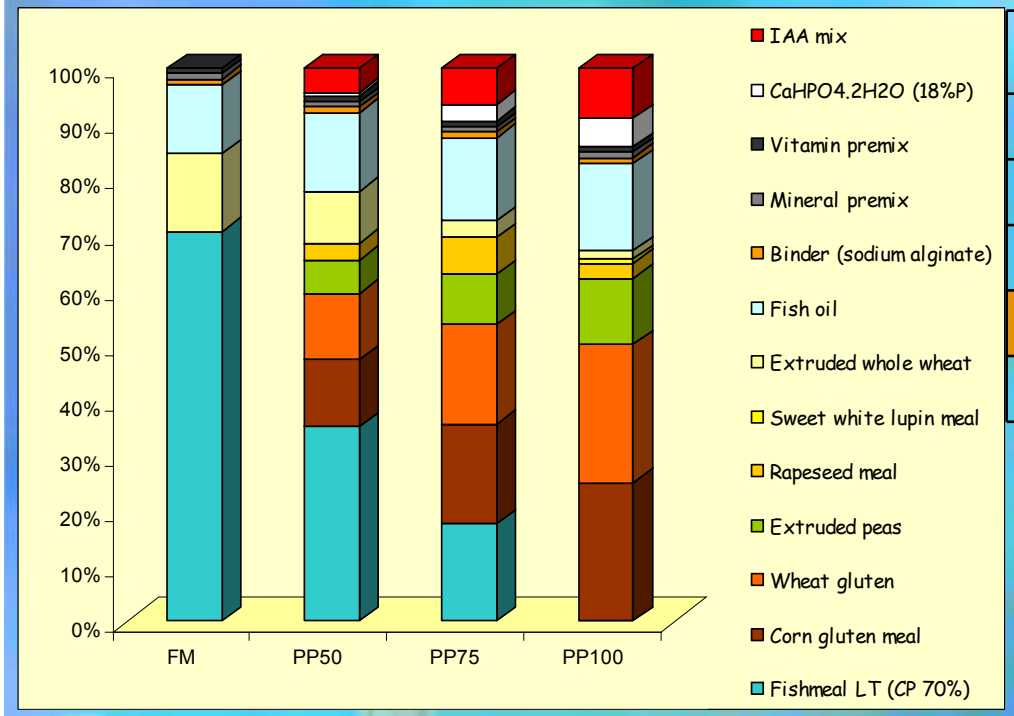
Protein / Lipid / Starch in bream diets



Fiskeriforskning

Fountoulaki et al. / Aquaculture Research 36 (2005) 1243-1251

Raw materials, FISH MEAL and FM substitution



Initial fish weight 16 g	FM	PP50	PP75	PP100
Final fish weight (g)	201 a	191 b	181 c	124 d
SGR	1,66 a	1,62 ab	1,59 b	1,3 c
FE	0,85 a	0,95 b	0,98 b	0,84 a
liver fat (%)	7,09 a	7,46 a	9,85 a	14,3 b
DM intake (g/fish)	239 a	185 b	169 c	128 d

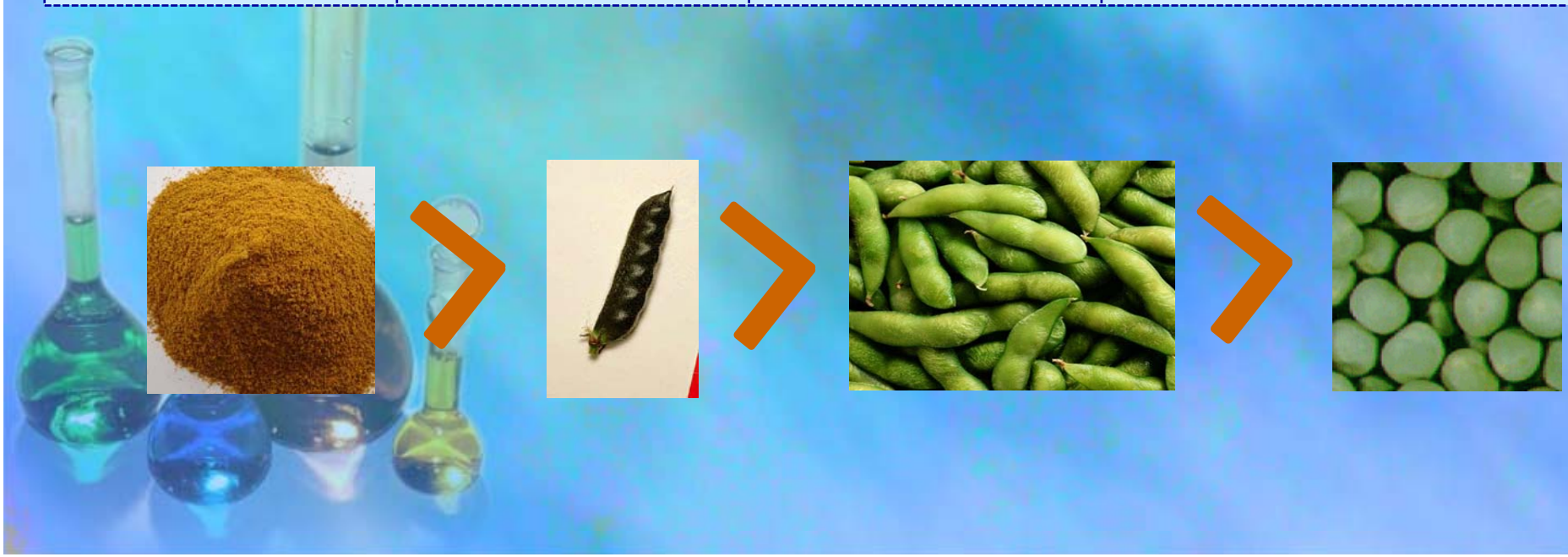
↑ fa synthetase, utilisation of surplus aa for lipogenesis?

Fish meal substitution (50-100%) significantly reduced feed intake and growth, improved FE, increased liver fat, affected plasma metabolites' concentration and immune system indicators (Sitzá-Bobadilla et al. / Aquaculture 249 (2005) 387-400).

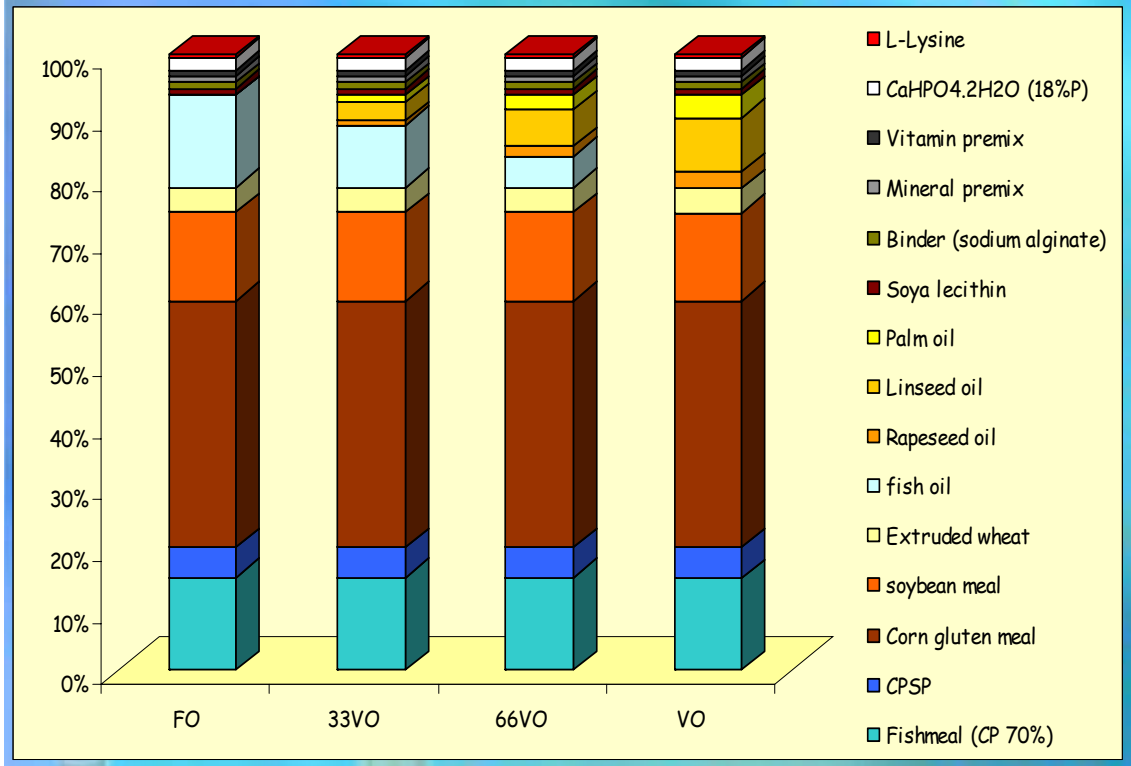
Replacement level	Raw materials	Source
75 % FM	FM=CG=WG>EP>RM	De Francesco et al. 2007
Effect (99-430 g bream):	Reduced: FI, FE, dress-out %, free ornithin, n-3 PUFA, MUFA, n-3/n-6 ratio, EPA, DHA. Increased: PER, HSI, total fillet and liver lipid, cholesterol, faa, n-6 PUFA.	

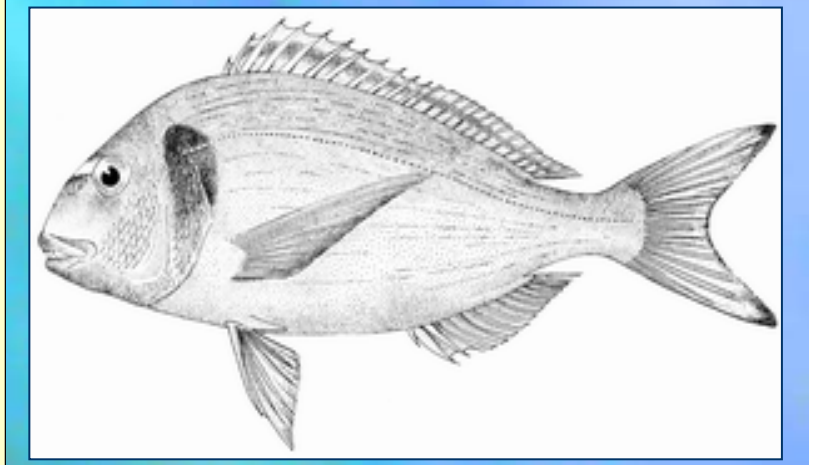
Raw materials, FISH MEAL and FM substitution

Protein source	Inclusion level	Fish size	publication
Field pea meal	10-20 % FM	5-30 g	Pereira et al. 2002
Soybean meal	20-22% diet	15-350 g	Martínez-Llorens et al. 2007
Corn gluten	60% FM	8-33 g	Pereira et al. 2003
Lupin meal	30% FM	43-158 g	Pereira et al. 2004
Veg. mix	?		

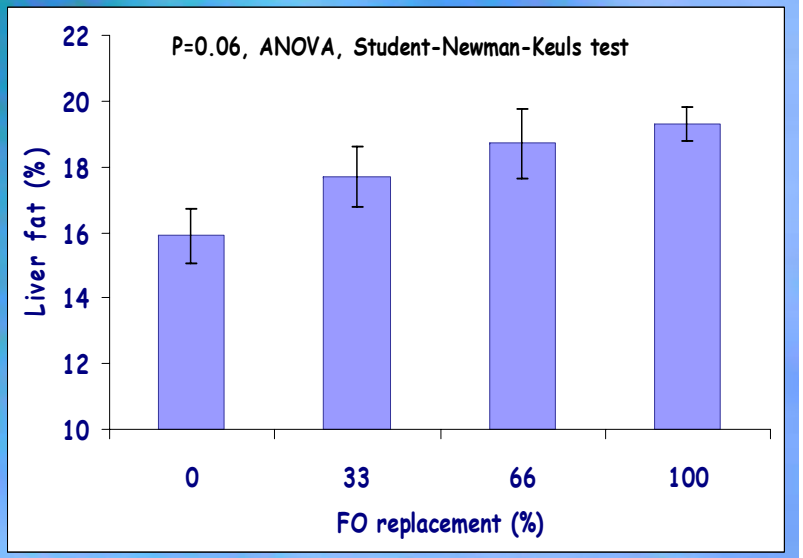


Raw materials, FO and FM substitution





16-90 g fish	FO	33VO	66VO	VO
DGI	2,68 a	2,66 a	2,66 a	2,43 b
FE	1,1	1,09	1,11	1,06
PER	2,21	2,23	2,25	2,14
DM intake (g/fish)	68,8 b	68,9 b	67,6 b	61,3 a



Fiskeriforskning

L. Benedito-Palos et al. / Aquaculture 267 (2007) 199-212

Raw materials, FISH OIL and FO substitution

Effects from FO replacement

Immune system

- EFA deficiency causes decrease in pathogen resistance & high levels n-6 fa reduces pathogen resistance (even if EFA requirements are fulfilled).
- 100% FO substitution by soybeen (SO) or leanseed oil (LO) or a mixture of the two reduces alternative complement pathway activity (**ACH50**) significantly
- 100 % substitution with single veg oil reduced significantly **Phagocytic index** (%) (Montero et al. 2007) but not when a mixture was used
- Vibriosis *Photobacterium damselae subsp. Damselae* (Dark skin; lethargy; distended abdomen; haemorrhages) ADVISE: Avoid use of feed with very high lipid levels

Raw materials, FISH OIL and FO substitution

Haematology

- 60% FO replacement with sunflower oil, cottonseed oil & SO (but not LO) induces:
  - increased thrombocyte counts
  - slight deformation in erythrocyte shape
  - elevated number of myelocytes and phagocytes in head kidney prints **(Wassef et al. 2007)**

Histology

- >50% FO replacement with SO ↑ liver & body fat levels in guvenile diets **(Kalogeropoulos et al. 1992)** indication of essential fatty acid deficiency
- 80% replacement by SO, LO and rapeseed oil (RO) up x5 lipid droplet accumulation in the intestine **(Caballero et al. 2003)**
- 60% FO replacement with SO causes intense liver steatosis, swollen hepatocytes and lipid accumulation **(Caballero et al. 2004; Wassef et al. 2007)**

Linoleic acid > linolenic acid > oleic acid

Raw materials, FISH OIL and FO substitution

Effects: Growth / Performance

- >33% replacement of FO reduces insuline-like growth factor I (**IGF-I**) (Benedito-Palos et al. 2007) good indicator in *S. aurata* for nutritional disorders due to amongs other reasons dietary protein source
- 72% FO replacement by SO reduces SGR significantly and affects fa composistion and fish sensoric characteristics (Martínez-Llorens et al. 2007)
- 100% FO substitution causes FCR increase and SGR depression (Montero et al. 2007)

6 months study, Differences became significant after 4 months

Fiskeriforskning

Fish processing by-prodycts, FO and FM substitution

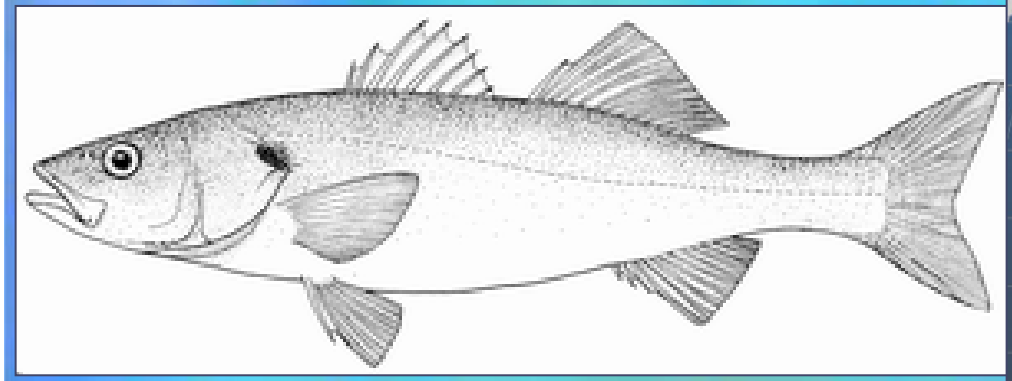
- High growth
- High FE
- No effect on body composition

50% FM & 100% FO replacement!

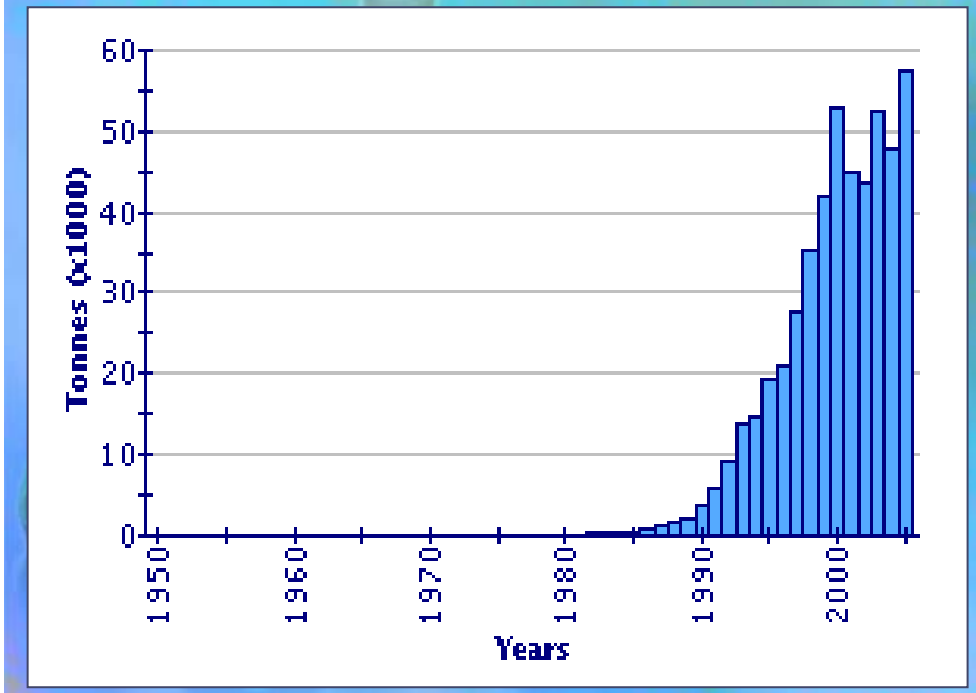
Fiskeriforskning

Kotzamanis et al. / Aquaculture Research 32 (2001) 288-295

European seabass, Dicentrarchus labrax (Linnaeus, 1758)

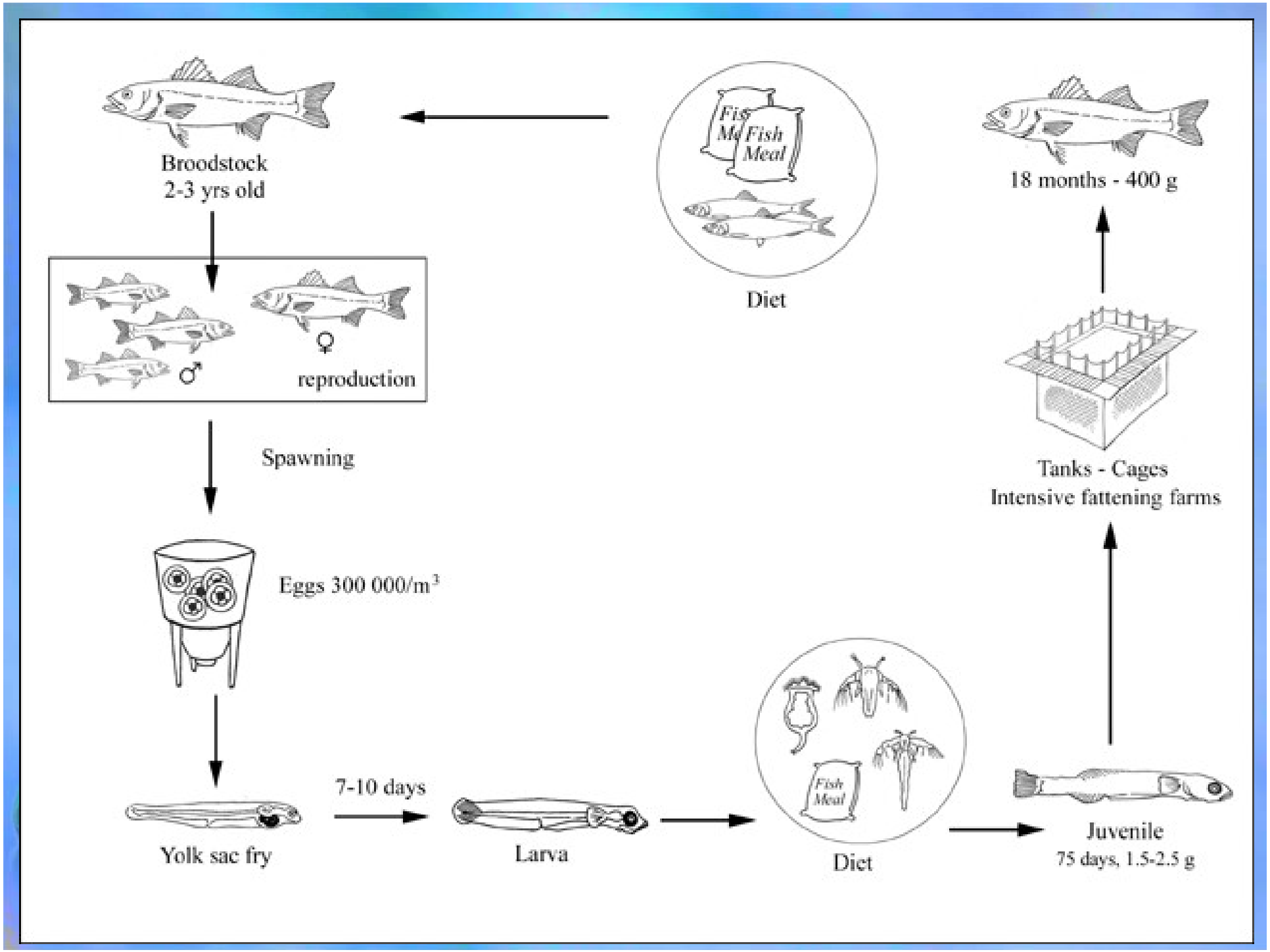


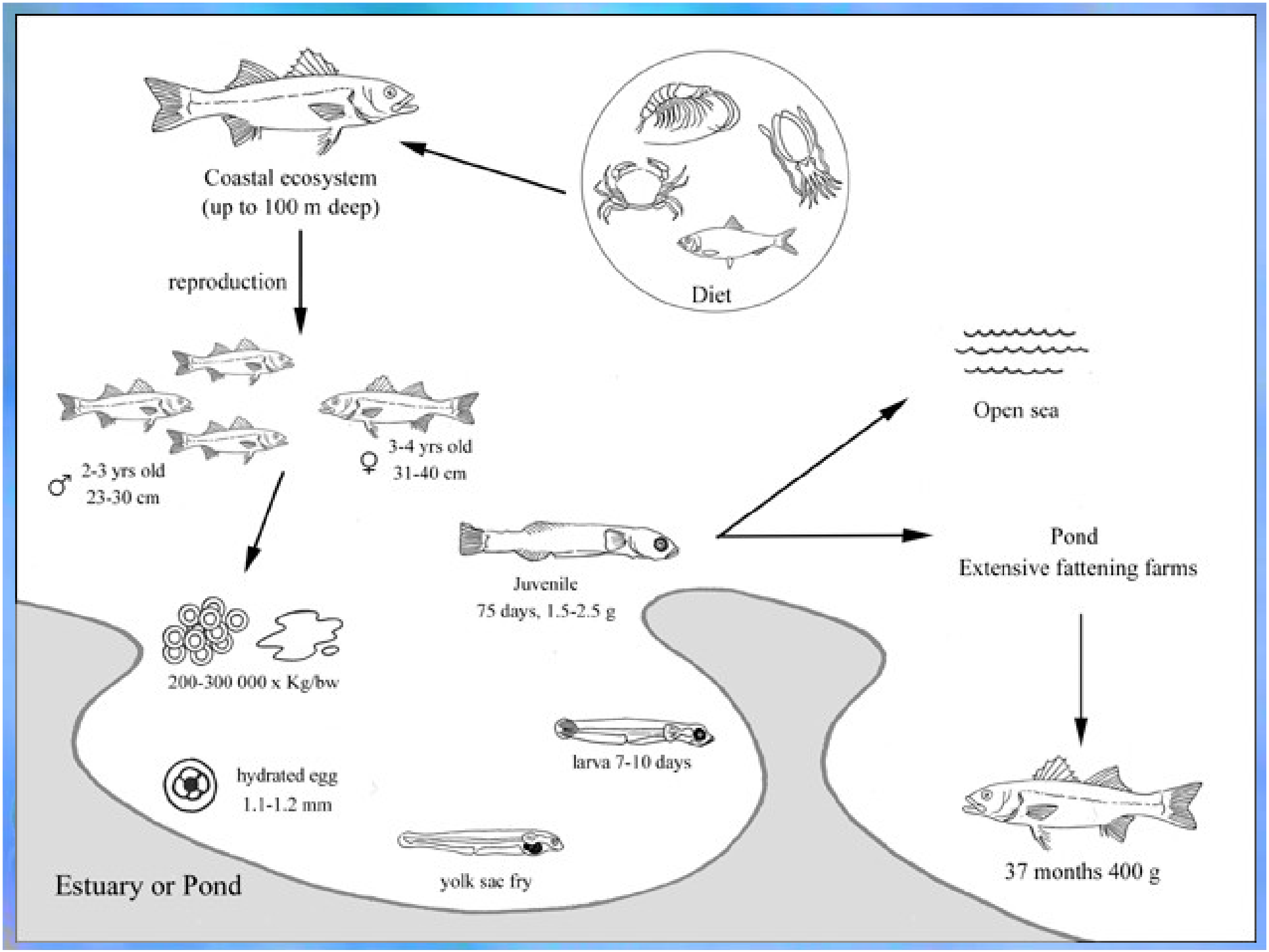
Main producer countries of Dicentrarchus labrax (FAO Fishery Statistics, 2002)



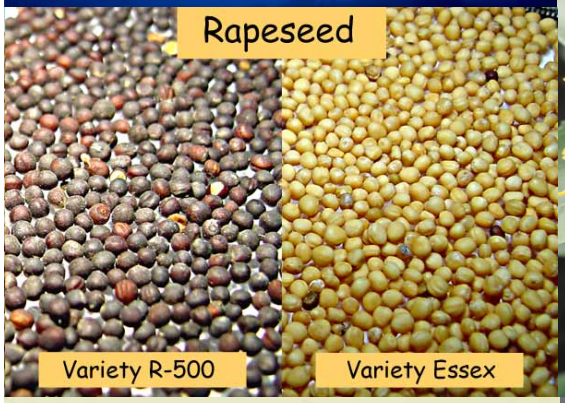
Global aquaculture production of Dicentrarchus labrax
(Fao Fishery Statistic)

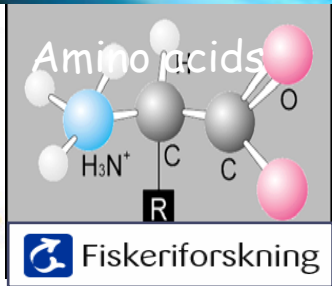
Fiskeriforskning


Broodstock
2-3 yrs old
Fish Meal
Diet
18 months - 400 g
♂
♀
reproduction
Tanks - Cages
Intensive fattening farms
Spawning
Eggs 300 000/m3
7-10 days
Yolk sac fry
Larva
Fish Meal
Diet
Juvenile
75 days, 1.5-2.5 g

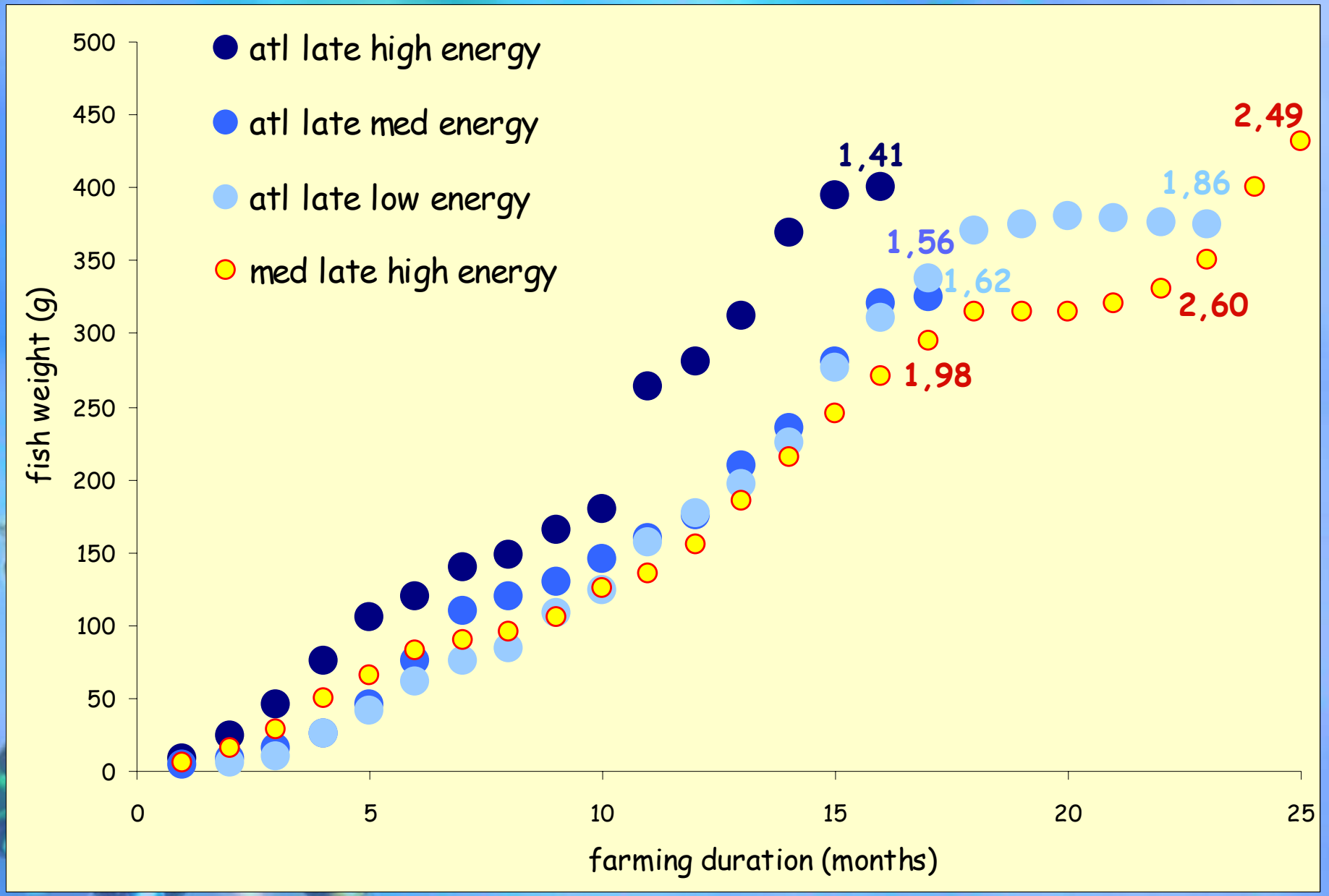

Coastal ecosystem
(up to 100 m deep)
reproduction
Diet
♂ 2-3 yrs old
23-30 cm
♀ 3-4 yrs old
31-40 cm
Open sea
Juvenile
75 days, 1.5-2.5 g
Pond
Extensive fattening farms
200-300 000 x Kg/bw
larva 7-10 days
hydrated egg
1.1-1.2 mm
yolk sac fry
37 months 400 g
Estuary or Pond

Raw materials in European seabass diets



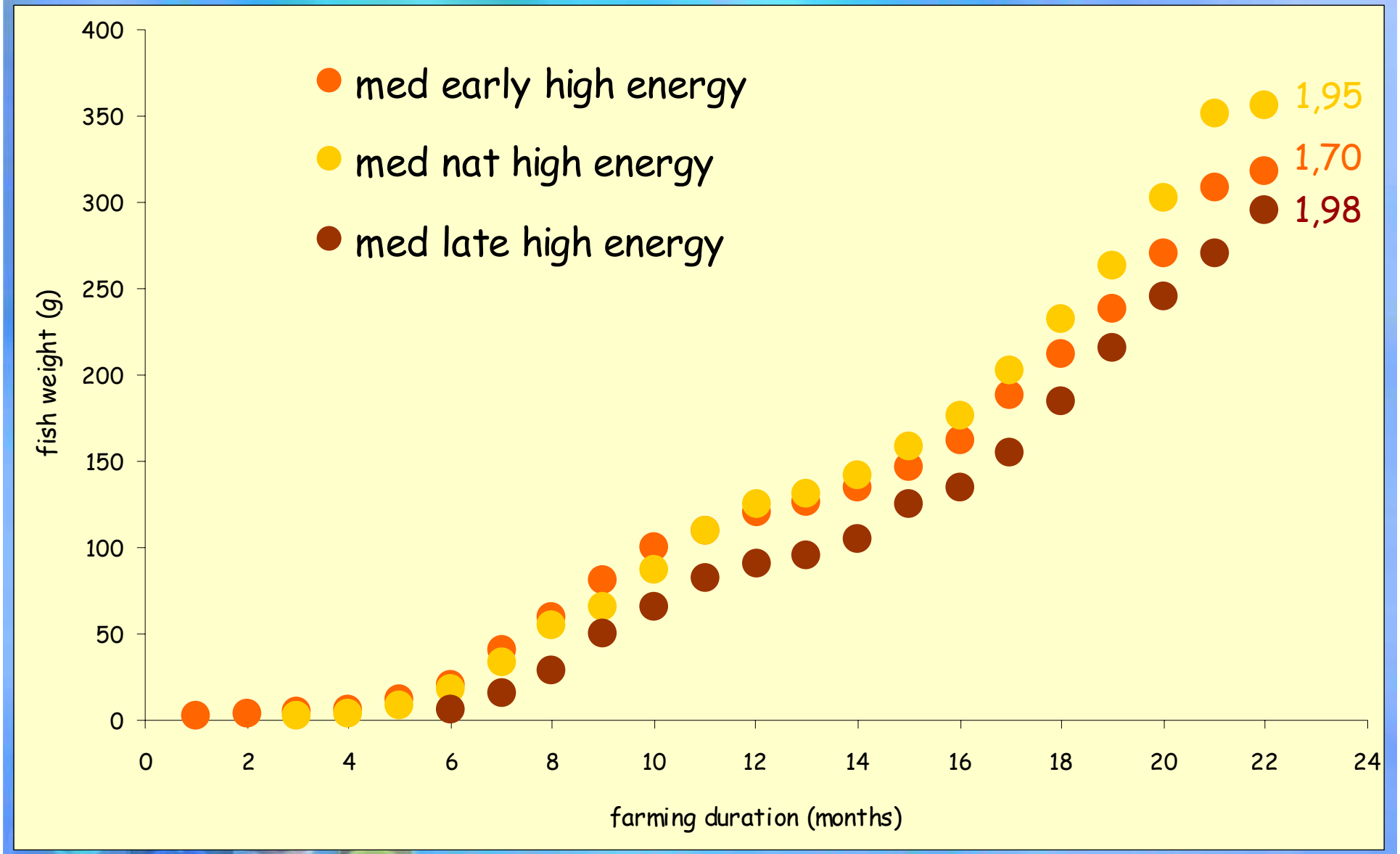


European sea bass on-growing performance 'strain / energy'

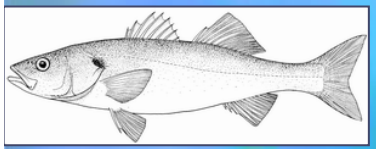


Fiskeriforskning

European sea bass on-growing performance 'stocking period'



Fiskeriforskning



Protein / energy

Juveniles

Protein: 48% DM / G. Energy: 19 kJ/g DM

Protein: 43% DM / G. Energy: 21 kJ/g DM

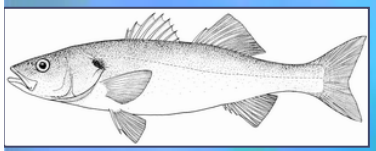
Reduced FE

Protein: 40% DM / G. Energy: 22.6 kJ/g DM

Digestible Starch 25%

Reduced FE, increased HSI and liver glycogen

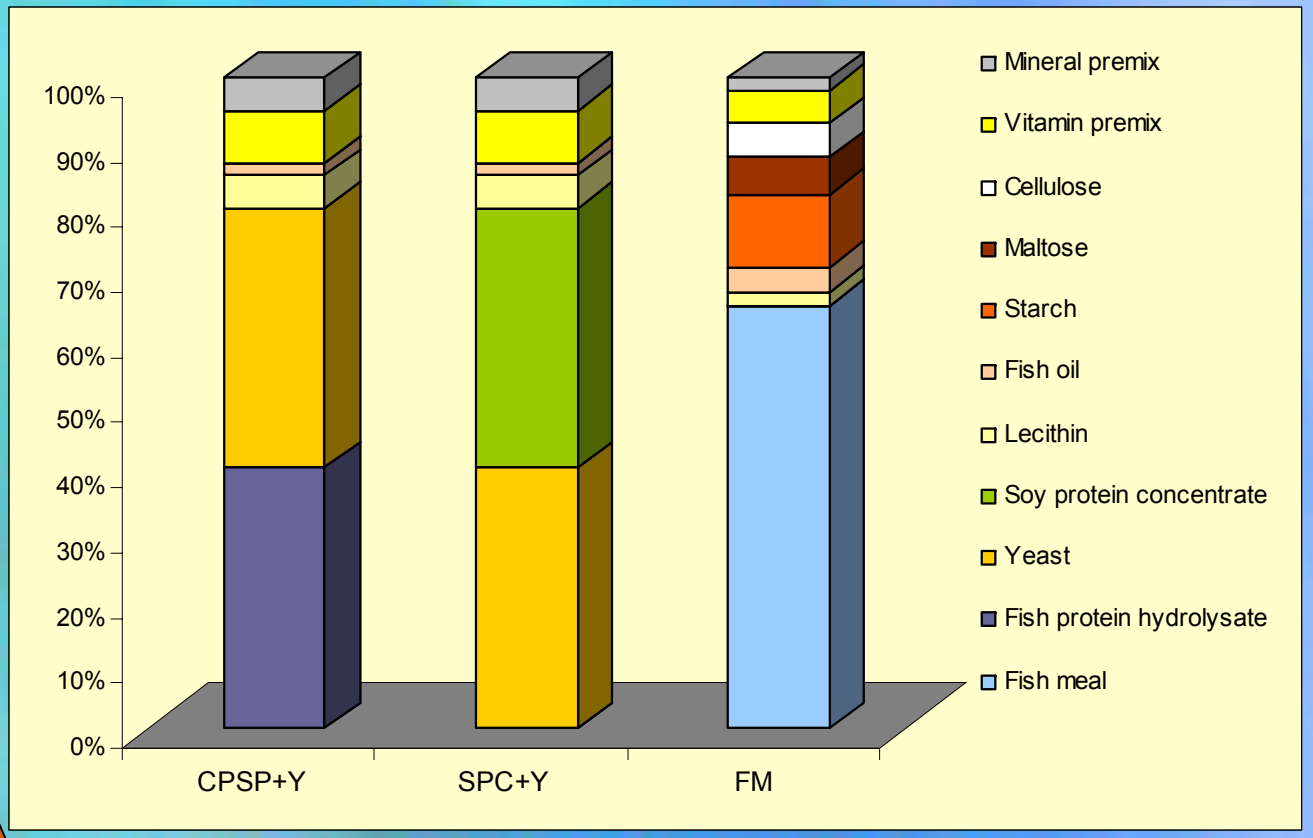
Fiskeriforskning



Fish protein hydrolysate + yeast

LARVAE:
first feeding

Use FPH + yeast
vs
Soy or Fish meal



55% survival
On live pray

	CPSP+Y	SPC+Y	FM
Final weight (g)	3.4 a	1.8 b	1.1 b
Survival (%)	35 a	14 b	19 b
Malformation rate (%)	13 a	19 b	24 c

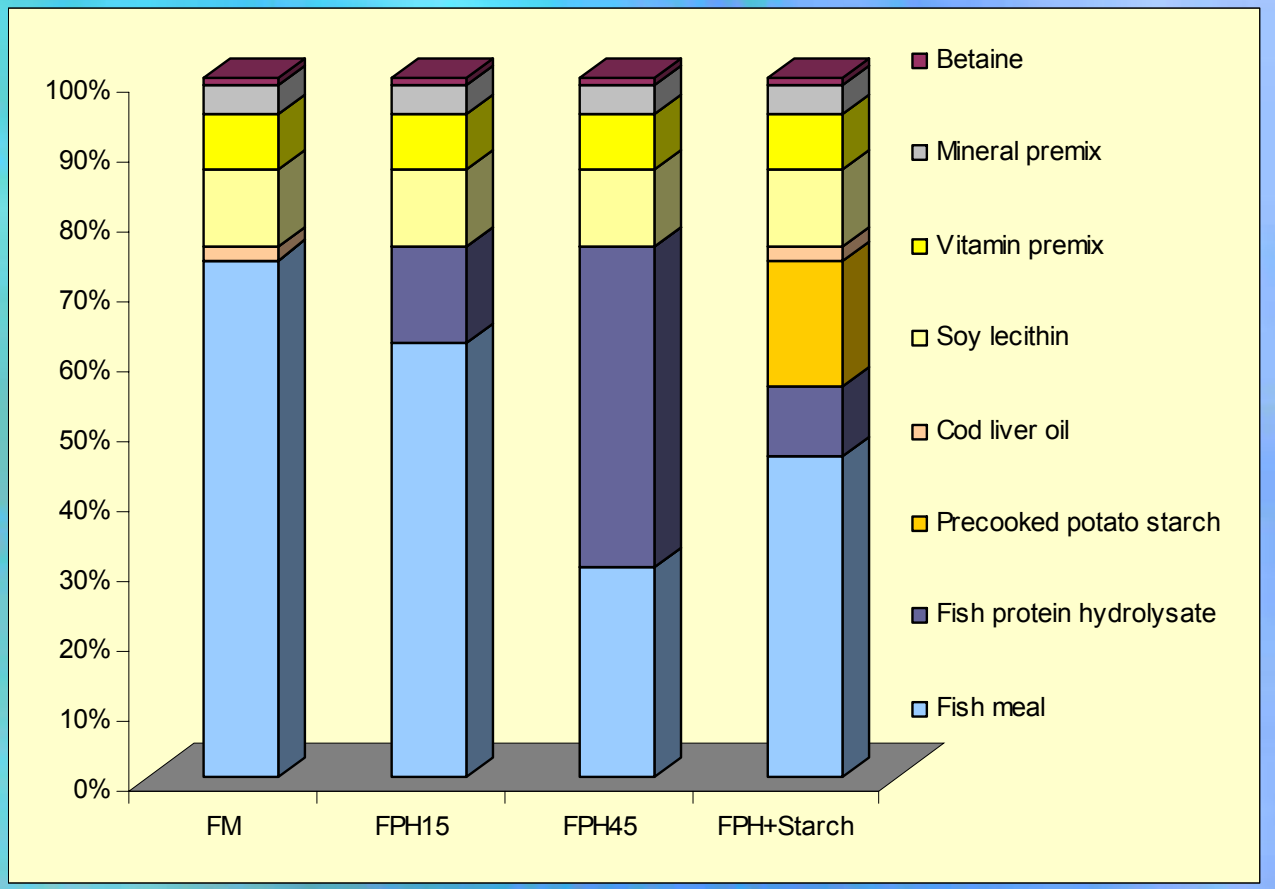
Fiskeriforskning

C. Cahu et al. / Aquacutlure (1998), 1-7

Fish protein hydrolysate

LARVAE:
first feeding

15% FPH = Fish meal
Starch: Growth reduction



55% survival
On live pray

	FM	FPH15	FPH45	FPH+Starch
Final weight (g)	21.6 a	19.7 a	5.6 b	9.5 b
Survival (%)	44.9 a	40.7 a	29.2 b	38.8 a

Induced ↑ trypsin activity

C. Cahu et al. / Aquacutlure (2004), 295-308

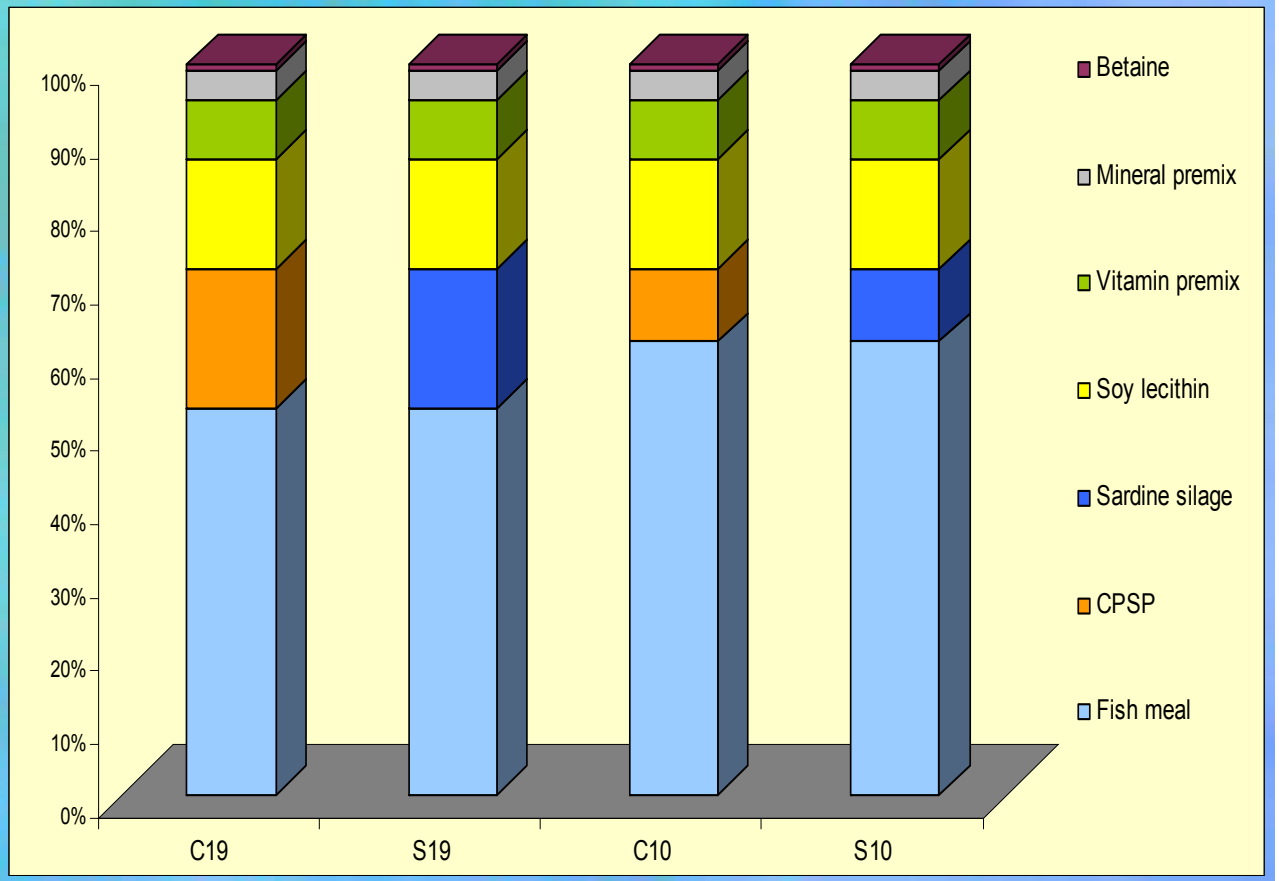
Fiskeriforskning

Fish protein hydrolysate

LARVAE:
first feeding

	DH (%)	<200 Da	200-500 Da	500-2500 Da	>2500 Da
CPSP	61,4	1,5	36,5	51,4	10,6
SH	46,5	4,3	54	35,2	6,5

C10:
- Higher growth
- Higher survival
- Improved intestinal activity
- Low level of *Vibrio* spp. counted



Fiskeriforskning

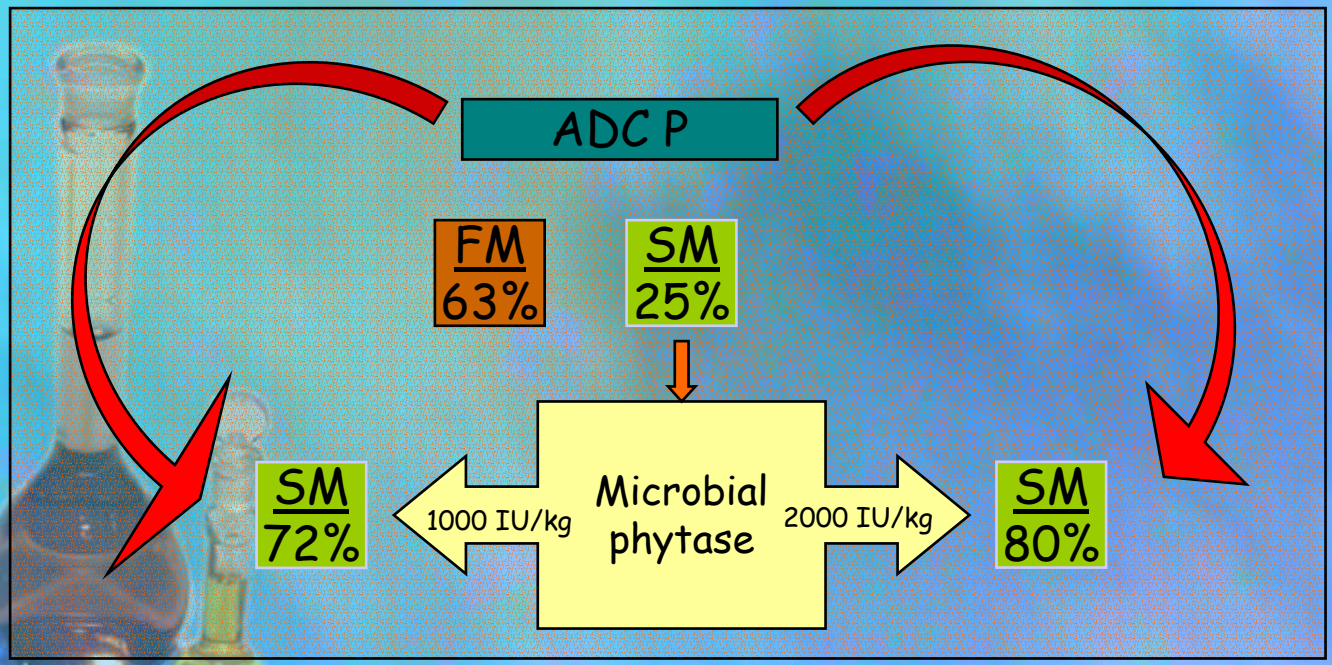
Y.P. Kotzamanis et al. / Comparative Biochemistry and Physiology, Part A (2007), 205-214

Fish meal and FM substitution

Juveniles

Soybean meal 66 % *vs* Fishmeal 69% protein

Growth, FE, N utilisation, P ADC depression



Fiskeriforskning

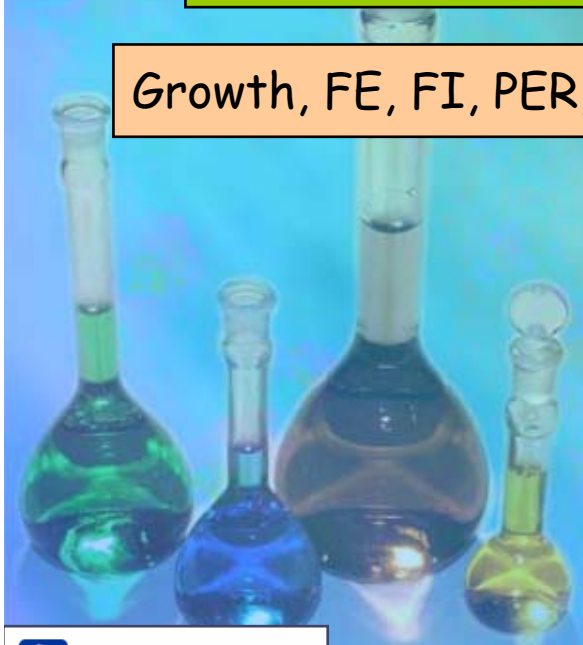
A. Oliva-Teles et al. / Aquatic living resources (1998), 255-259

Fish meal and FM substitution

Juveniles

Extruded peas and SPC or Corn gluten meal 80% of Fishmeal protein

Growth, FE, FI, PER, N utilisation & lipid, starch, DM, P & E ADP depression



ADC Soy protein concentrate > ADC Corn gluten meal

Fiskeriforskning

J. Dias et al. / Comparative Biochemistry and Physiology, Part A 142 (2005), 19-31

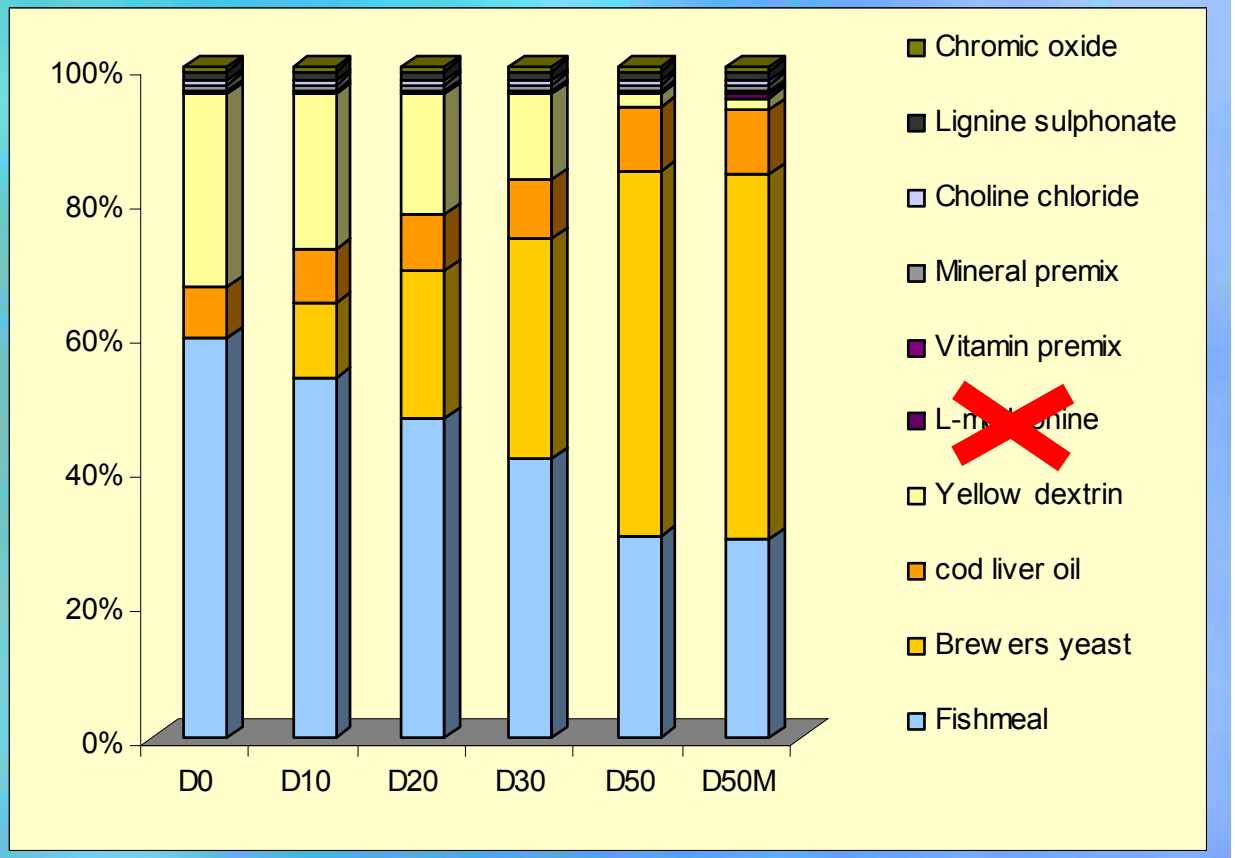
Fish meal and FM substitution

Juveniles

Fishmeal substitution with Brewers yeast

Up to 30% Diet N from brewers yeast,
(A. Oliva-Teles,P. Gonçalves / Aquaculture 202 (2001) 269-278)

Yeast products



	D0	D10	D20	D30	D50	D50M
SGR	1.46 ab	1.52 ab	1.53 ab	1.60 b	1.46 ab	1.42 a
FCR	1.48 a	1.35 bc	1.38 b	1.28 c	1.42 ab	1.43 ab
PER %	20.8 a	25.6 bc	24 bc	26.5 c	24.7 bc	22.8 ab
Energy retention %	26	29.8	27.1	30.7	27.6	25.8

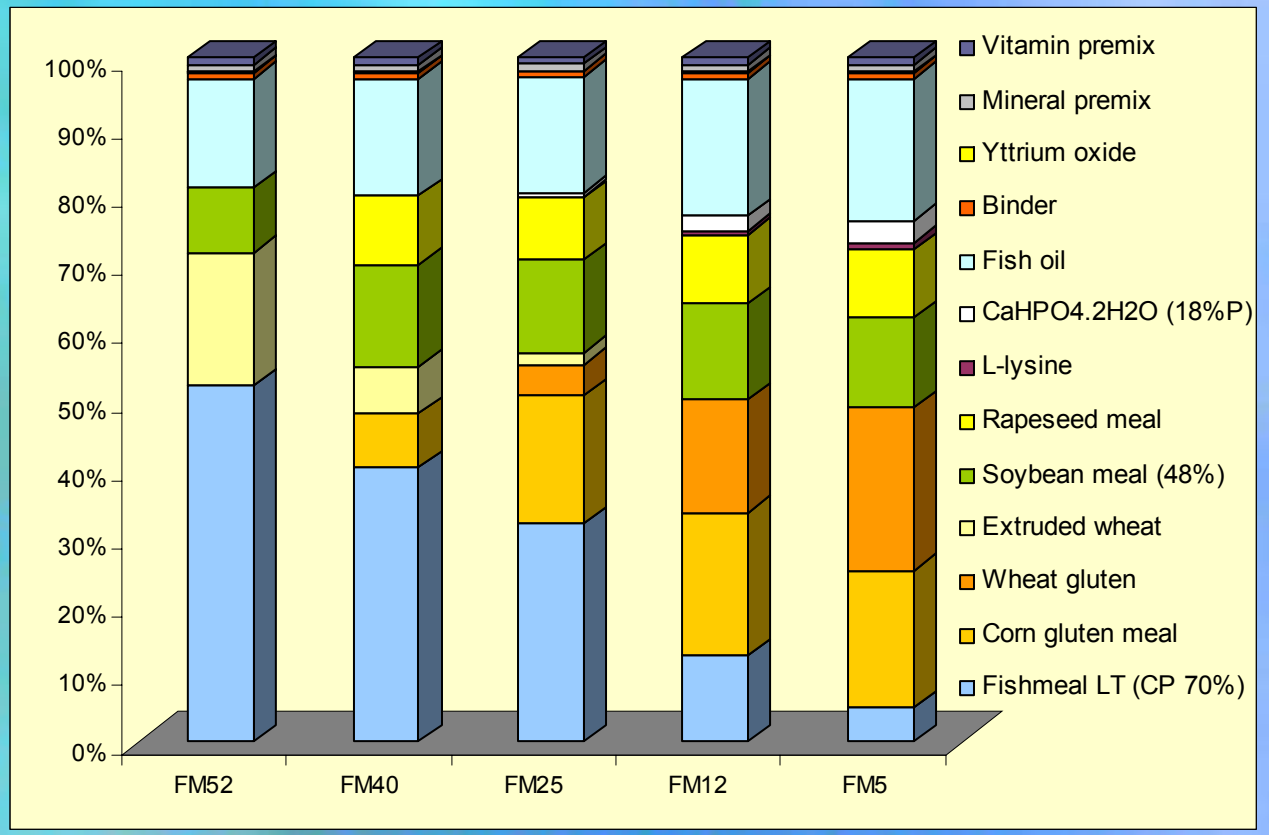
Fiskeriforskning

Fish meal and FM substitution

On-growing

PER FM52 < Veg Mix Diets

N losses
aa imbalance ?
execss supply ?



	FM52	FM40	FM25	FM12	FM5
Initial fish weight (g)	190	190	190	190	190
Final fish weight (g)	330,8	333,2	317,2	327,3	313,9
DGI	1,36 ab	1,48 a	1,34 ab	1,38 ab	1,25 b
FE	0,68	0,68	0,69	0,68	0,65
PER	1,51 a	1,41 ab	1,36 bc	1,46 ab	1,28 c

Fiskeriforskning

S.J. Kaushik e al. / Aquaculture 230 (2004) 391-404

Fish oil and FO substitution

On-growing

FO

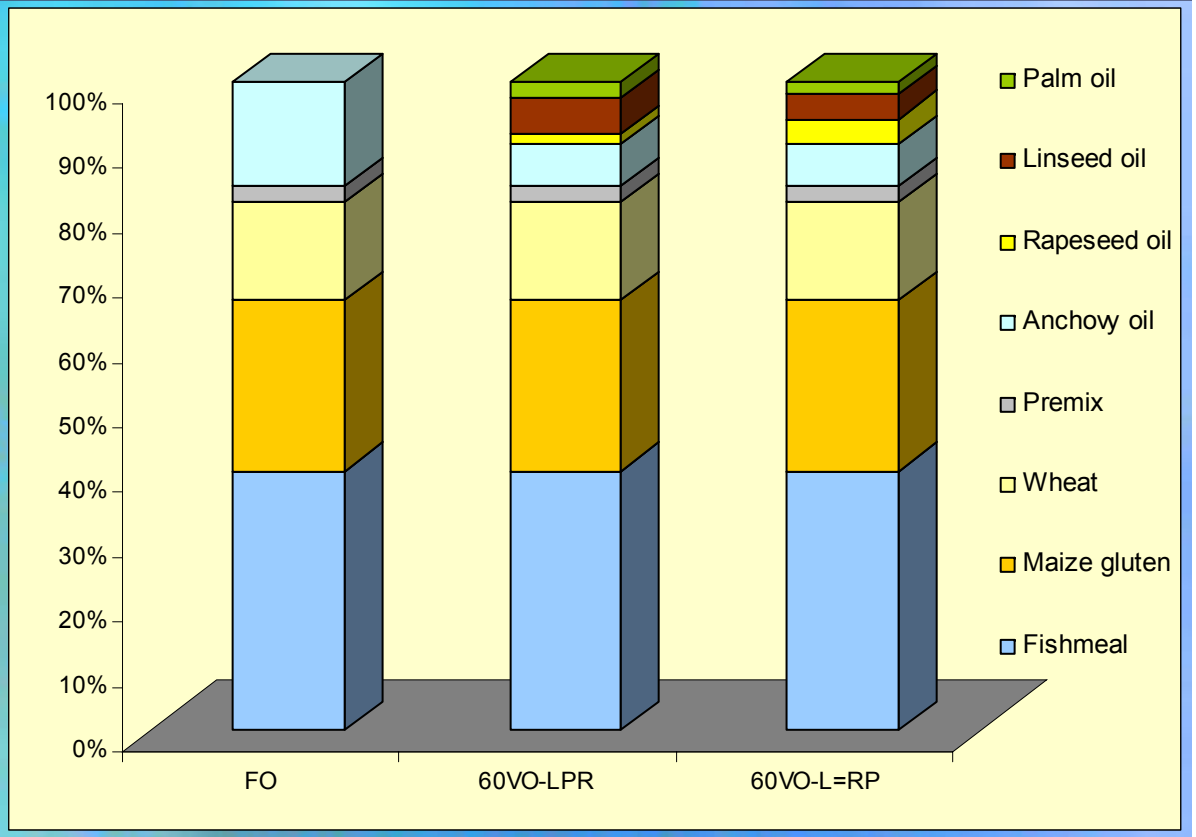
VMix1

VMix2

Low fa desaturase/
Elongase activity

Hepatocytes
&
enterocytes

High β-oxidation
activity



	FO	60VO-LPR	60VO-L=RP
Initial weight (g)	5,2	5,2	5,2
Final weight (g)	176,2	143,2	159,8
SGR	0,786	0,74	0,764

Fiskeriforskning

G. Mourente et al. / Aquaculture 248 (2005) 173-186

Raw materials - Minerals

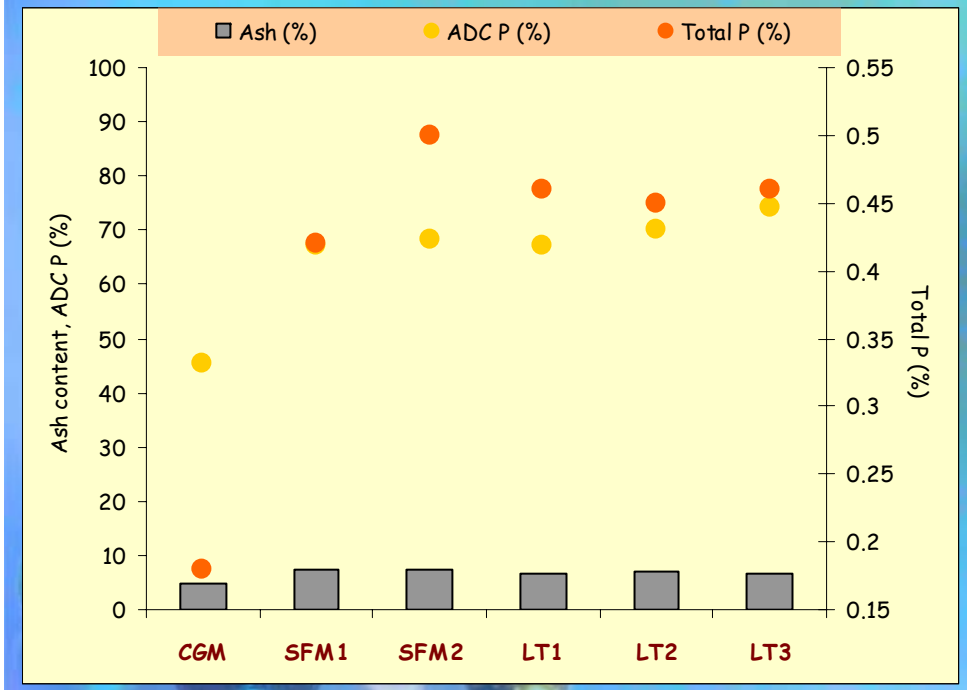
Phosphorus requirement: 0,65 %/ 0,44% available

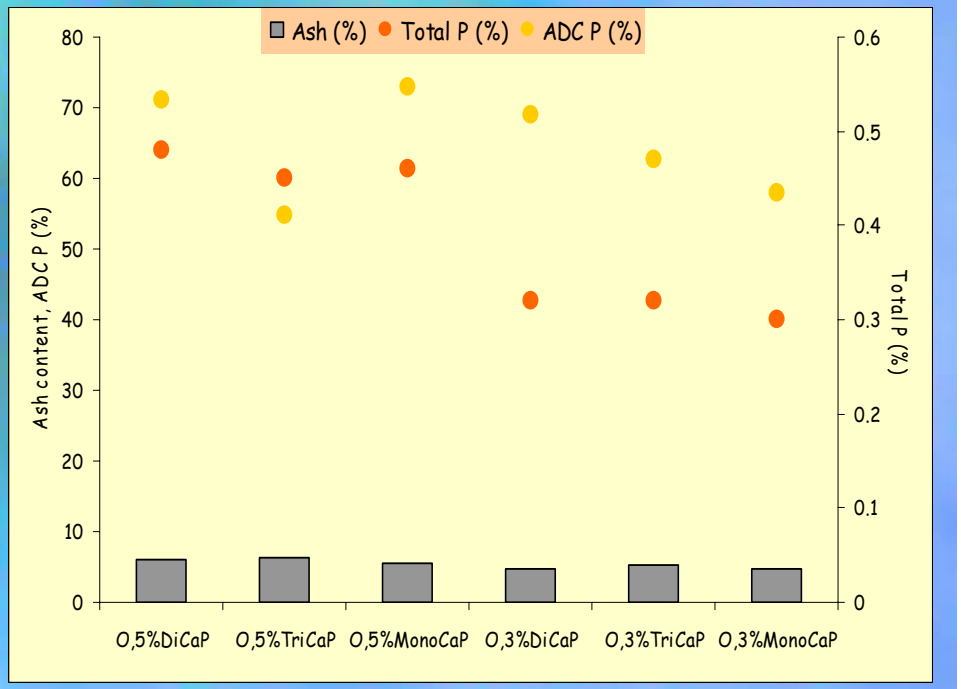
(Oliva-Teles et al. 2004)

P ADC 67-74% LT ≥ 71-73% MCaP/DCaP > 68-69% SFM > 45% CGM

(A. Pimentel-Rodrigues et al. Aquaculture 2007)

0.45% Total P





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Raw materials - Additives

Juveniles

Yeast RNA (6.2-12.4%)

Does not improve growth or feed efficiency & induces a decrease in Nitrogen retention
(H. Peres, A. Oliva-Teles / Aquaculture 215 (2003) 245-253)

Crystalline amino acids

Juveniles

Agar coated Crystalline-AA (60/40: EAA/NEAA) replacement 24% of diet protein (FM)

Improved FE and N retention – 32.5 % N intake

50/50: EAA/NEAA → Max growth

H. Peres, A. Oliva-Teles / Aquaculture 256 (2006) 395-402

Agar coated crystalline-AA (FM, WBC, REQ) 60% of diet protein (FM) was replaced

Control>FM>WBC>REQ

SGR, FE, N/E retention

H. Peres, A. Oliva-Teles / Aquaculture 267 (2007) 119-128

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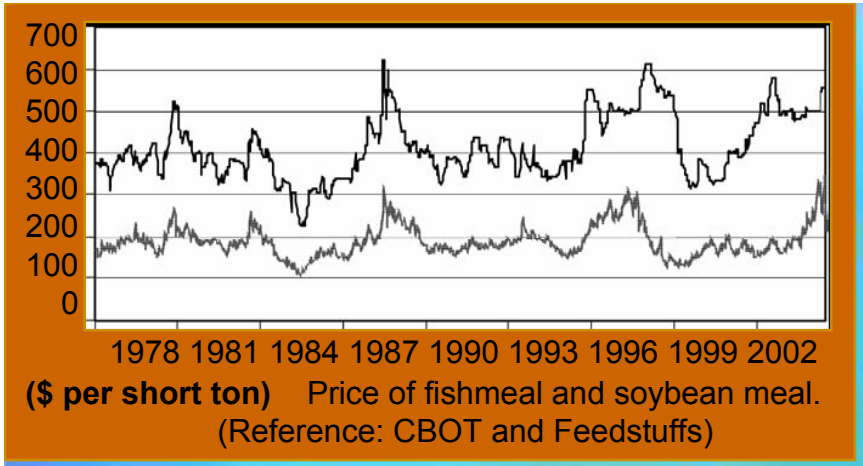

Land animal by-product hydrolysates (not yet allowed to be used in fish feeds in Europe)

attractants

Plant origin (price?)

Nutritional equilibrium of diets

PP & PO

Crystalline AA

FM&FO

By-products

Protein hydrolysates

Bone meal

Method/ level / fraction ?

Bacterial protein

Availability

FM, FO…

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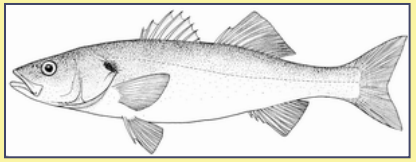
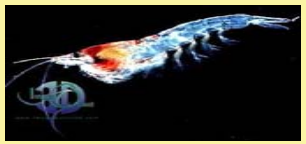
International Cooperation

Essential amino acid requirements (% protein)

Raw material digestibility/ properties









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NOFIMA

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Thank you very much!!!

Questions?

Dinner time...

Healthier fish can give you better health

We humans can reap health benefits by eating extra-healthy farmed fish. But for the good properties of the fish to be even better, it is crucial that the feed it eats is composed of health-promoting ingredients. Since is it not only marine fat that makes seafood healthy, Fiskeriforskning is studying the content of other components in fish feed that have positive health effects. By increasing the amount of these natural components in the feed, this can have positive health effects for fish consumers.

The healthy properties of fish and other seafood are generally associated with polyunsaturated fatty acids, particularly Omega 3. While for many years there has been much research activity around marine fat and its effect on our health, little has been done to study the importance of other components in seafood. Now scientists are working to discover which substances in salmon feed have positive health effects. The feed consists mainly of oil and meal, which are again based on various types of fish like sandeel and blue whiting, as well as vegetable raw materials such as corn and soy.

"We know that there are other components than the fat in marine raw materials that explain why this is healthy food, such as minerals and substances that contain nitrogen", explains Senior Scientist Anders Aksnes.

Scientist Anders Aksnes looking for components in fish feed that can give us better health. These are some of the more than 30 different substances that are being analysed.

Fiskeriforskning is currently analysing the levels of more than 30 different components in the feed, the majority of which are of marine origin.

"We believe there are many components that have a positive effect, and which we will continue working with. These are components that we know from other studies have a wide range of effects on people's health, including substances that are favourable for the cardiovascular system, prevent cancer, stimulate the immune system and contribute to improved restoration of health after illness.

Components that appear to be promising will be tested in various diets with several different groups of fish.

"In the final phase, we are planning a study where people will eat fish that is raised on the different feed varieties, thereafter to measure the health-related effect on the human body", says Aksnes.

Extensive research on seafood

The research on health-promoting components in fish feed is being conducted in collaboration with feed manufacturer Biomar. The project is a part of the research programme SEAFOODplus, which has been started up by the EU and has a total budget of 200 MNOK. Fiskeriforskning is the second largest partner in the programme, where a number of European business institutes will contribute to ensure that European consumers get safe seafood products of high eating quality. It will also result in environmentally friendly and ethically sound aquaculture production methods.