Present status and future prospects of Korean and world aquaculture,

and development of low pollution diets for the sustainable, environmentally and economically sound aquaculture

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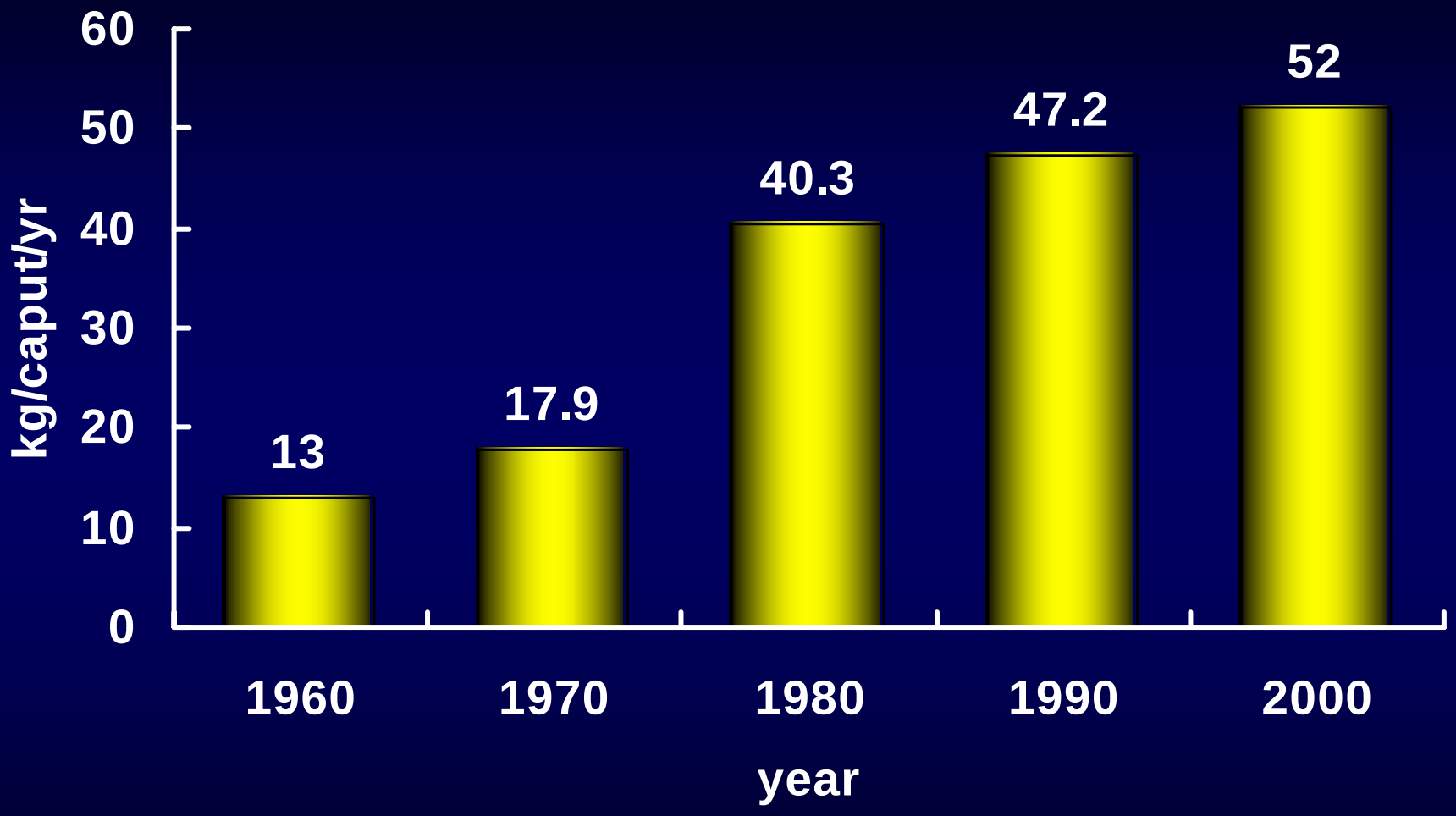
I. Status and Prospects of Korean Aquaculture

Republic of Korea

- 9,000 km of coastline
- 3,000 islands
- Four seasons
- Abundant and diverse marine organisms



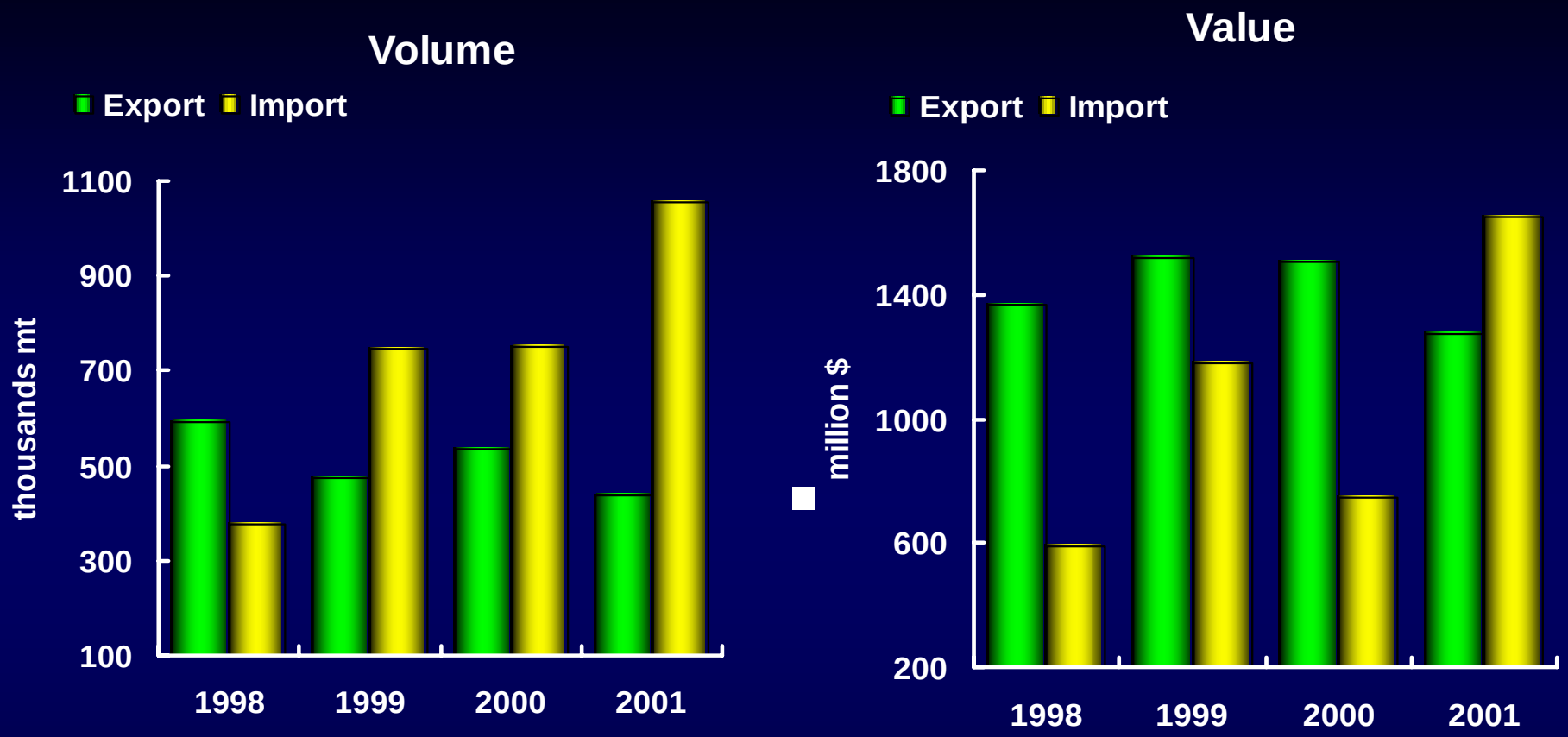
Source: FAO FISHSTAT plus statistic database (2003)

Per caput seafood consumption trends in Korea :1960 - 2000

Capture and Aquaculture Production in Korea (1000mt)

	1970	1980	1990	1995	2000	2001
Marine catch	816	1,830	2,467	2,323	1,841	1,991
Mariculture	119	541	772	996	653	656
Fresh. catch	0.38	38	19	9	7	6
Fresh. culture	0.02	1	16	20	13	12
Total capture	816	1,868	2,486	2,332	1,848	1997
Total aquaculture	119	542	788	1,016	666	668
Grand total	935	2,410	3,274	3,348	2,514	2,665

The Fisheries Association of Korea (2002)



Source: The Fisheries Association of Korea (2002)

Exports and imports of fishery products

Total Marine Aquaculture Production in Korea

(1000mt)

	1970	1980	1990	1995	2000	2001
Finfish	0.02	0.04	2.7	8.4	26.0	29.2
Crustacean	0.01	0.09	0.3	0.4	1.2	2.1
Mollusc	74.9	282.6	357.9	338.6	251.8	217.1
Seaweed	44.1	257.9	411.9	649.1	374.5	373.5
Total	119.0	540.6	772.8	996.5	653.5	665.8

The Fisheries Association of Korea (2002)

Total Freshwater Aquaculture Production in Korea

(mt)

	1970	1980	1990	1995	2000	2001
Finfish	17	956	15,278	20,305	13,212	11,678
Crustacean	-	-	1	11	21	30
Mollusc	-	38	545	49	230	358
Algae	-	-	13	-	7	-
Total	17	994	15,837	20,365	13,470	12,170

The Fisheries Association of Korea (2002)

Marine and Freshwater Aquaculture Production in 2001

(mt)

Group	Mariculture	Freshwater Aquaculture
Finfish	29,297	11,678
Crustacean	2,081	30
Mollusc	217,078	358
Seaweed	373,358	-
Total	**655,827**	**12,170**

The Fisheries Association of Korea (2002)

Black sea bream, ***Acanthopagrus schlegeli***

Sweet fish, ***Plecoglossus altiveliss***

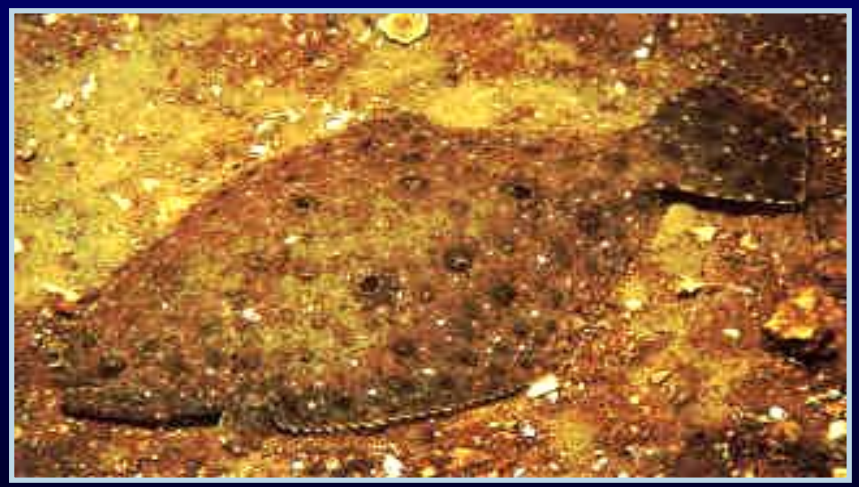
Parrot fish, ***Oplegnathus faciatus***

Mountain trout, ***Oncorhynchus masou***

Major Marine Finfish Culture Production in Korea (mt)

Species \ Year	1990	1994	1996	1998	2000	2001
Flounder	1,037	16,399	29,213	39,648	39,932	40,066
Rockfish	386	4,406	22,565	29,950	39,148	40,775

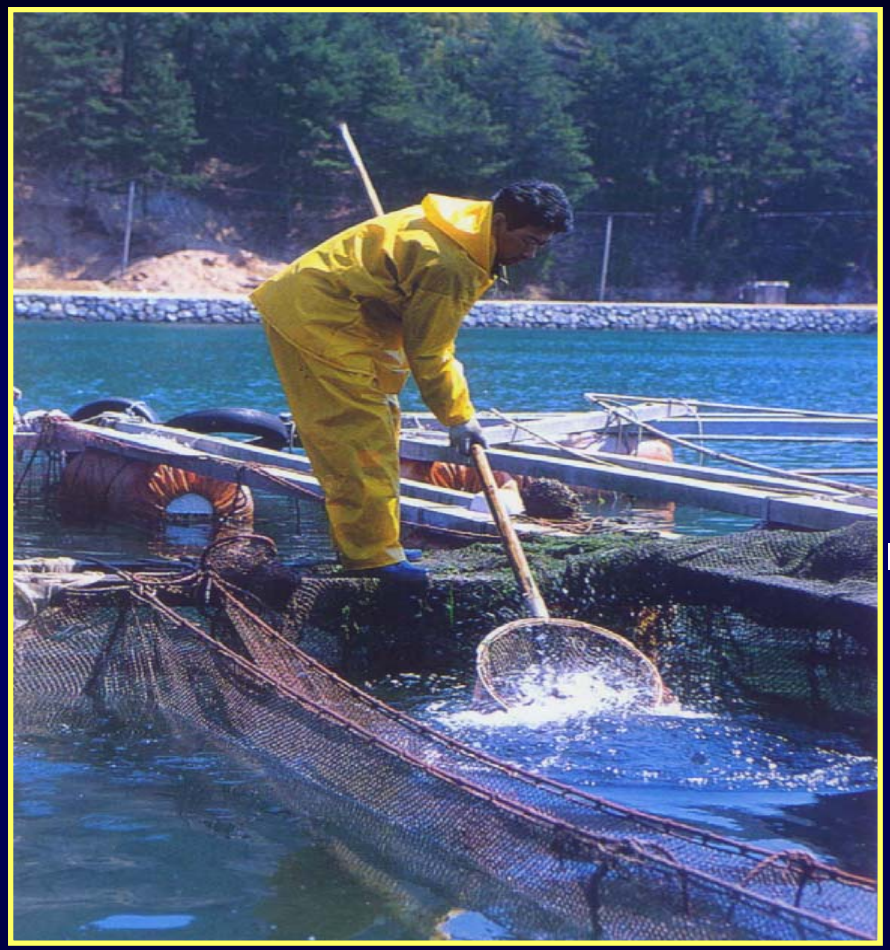
National fisheries Research and Development Institute (NFRDI)



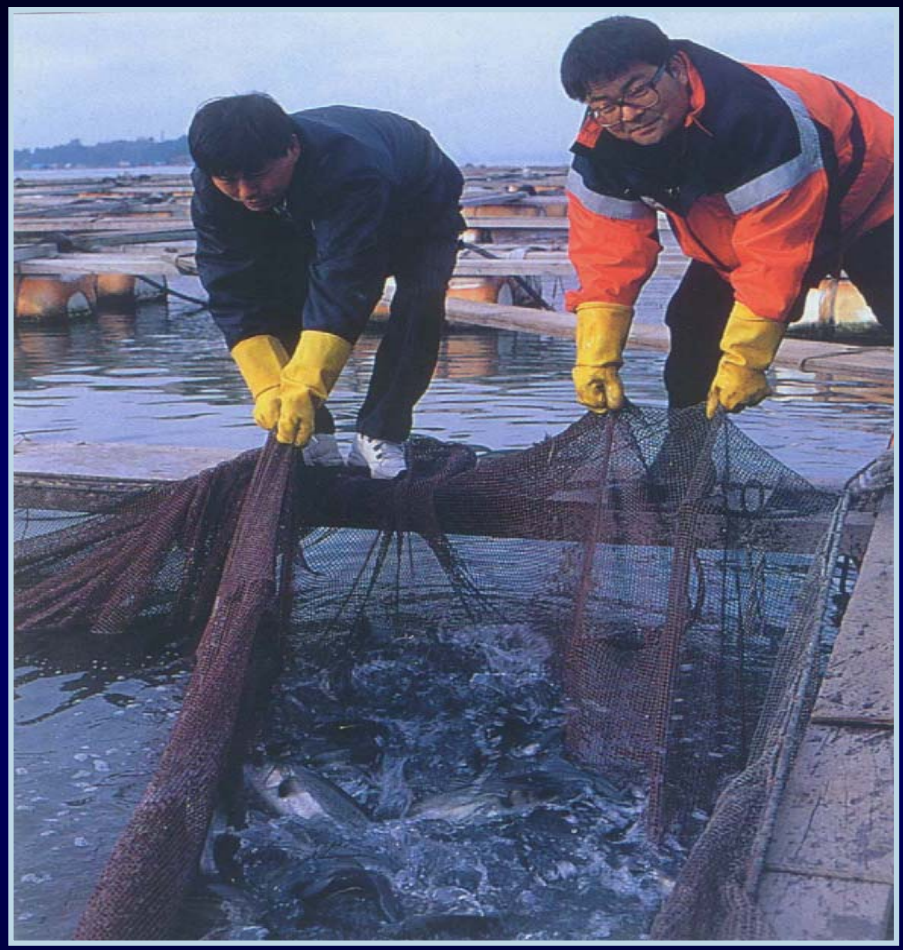
Olive flounder, *Paralichthys olivaceus*

Black rockfish, *Sebastes schlegeli*

A cage culture sites in Korea



Harvesting and grading black rockfish from the sea cage



Harvesting yellowtail from the sea cage

Grading juvenile olive flounder at a land-based tank farm

Semi-recirculating land-based tank farm

Fleshy shrimp, *Penaeus chinensis*

Kuruma prawn, *Penaeus japonicus*

Marine Mollusc Culture Production and Species in 2001

(mt)

Major species	212,868	Other species	3,931
Oysters	174,117	Cockles	3,842
Short neck	16,433	Venus clam	25
Stalked sea squirt	-	Abalones	29
Sea mussel	13,653	Top shell	3
Arkshell	7,359	Hen cockle	6
Scallop	66	Hard clam	26
Sea squirt	-	Egg cockle	-
Pen shell	1,240	Surf clam	-
Total			**217,078**

The Fisheries Association of Korea (2002)

Abalone, *Haliotis discus hannai*

Senatorial scallop, *Gloriopallium pallium*

Scallop (Giant ezo scallop), *Patinopecten yessoensis,* are cultured in the region along the eastern coastal area

Workers Harvest and grade oysters from net bags suspended from rafts

Pacific oyster, *Crassostrea gigas*

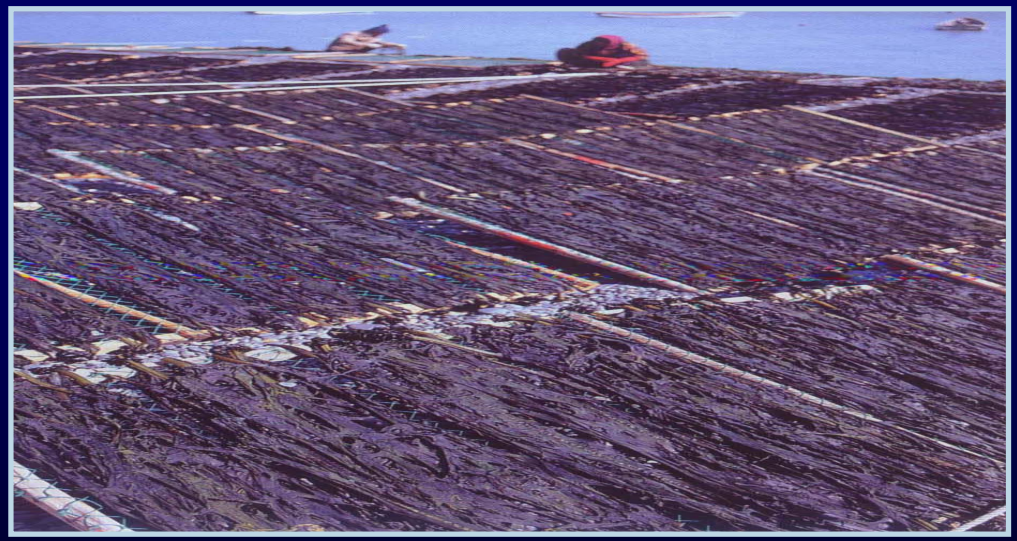
Marine Seaweed Culture Production and Species in 2001

	(mt)
Sea mustard	175,490
Laver	167,909
Kelp	17,506
Fusiforme	6,865
Green laver	5,760
Sea staghorn	7
Others	1
Agar-agar	
Codium	
Total	**373,538**

The Fisheries Association of Korea (2002)

Sea mustard harvested from raft ropes (right)

Fixed and semi-floating culture systems are used for laver production (above)



Dried sea mustard (above) is one of the most important processed seaweed products

Freshwater Finfish Aquaculture Production and Species in 2001

(mt)

Major species	10,880	Other species	560
Trout	2,834	Colored carp	49
Mud fish	2,567	Snake head	333
Eel	2,644	Sweet fish	65
Israeli carp	1,212	Korean bullhead	47
Tilapia	609	Gold fish	35
Common carp	372	Mountain trout	31
Loach	642	Others	
Total			**11,678**

The Fisheries Association of Korea (2002)

Other Freshwater Aquaculture Production and Species in 2001 (mt)

Crustacean	**30**	**Algae**	**-**
Crabs	21	Water shield	-
Shrimps	9	Others	-
Shellfish	**358**	**Other aquatic animal**	**104**
Snail	40	Turtle	104
		Others	-
Total			**231**

The Fisheries Association of Korea (2002)

Present and Future Demand for the Total Fisheries Production in Korea

2000

Total consumption	5,000,000 mt
Fisheries production Imported	750,000 mt

2010

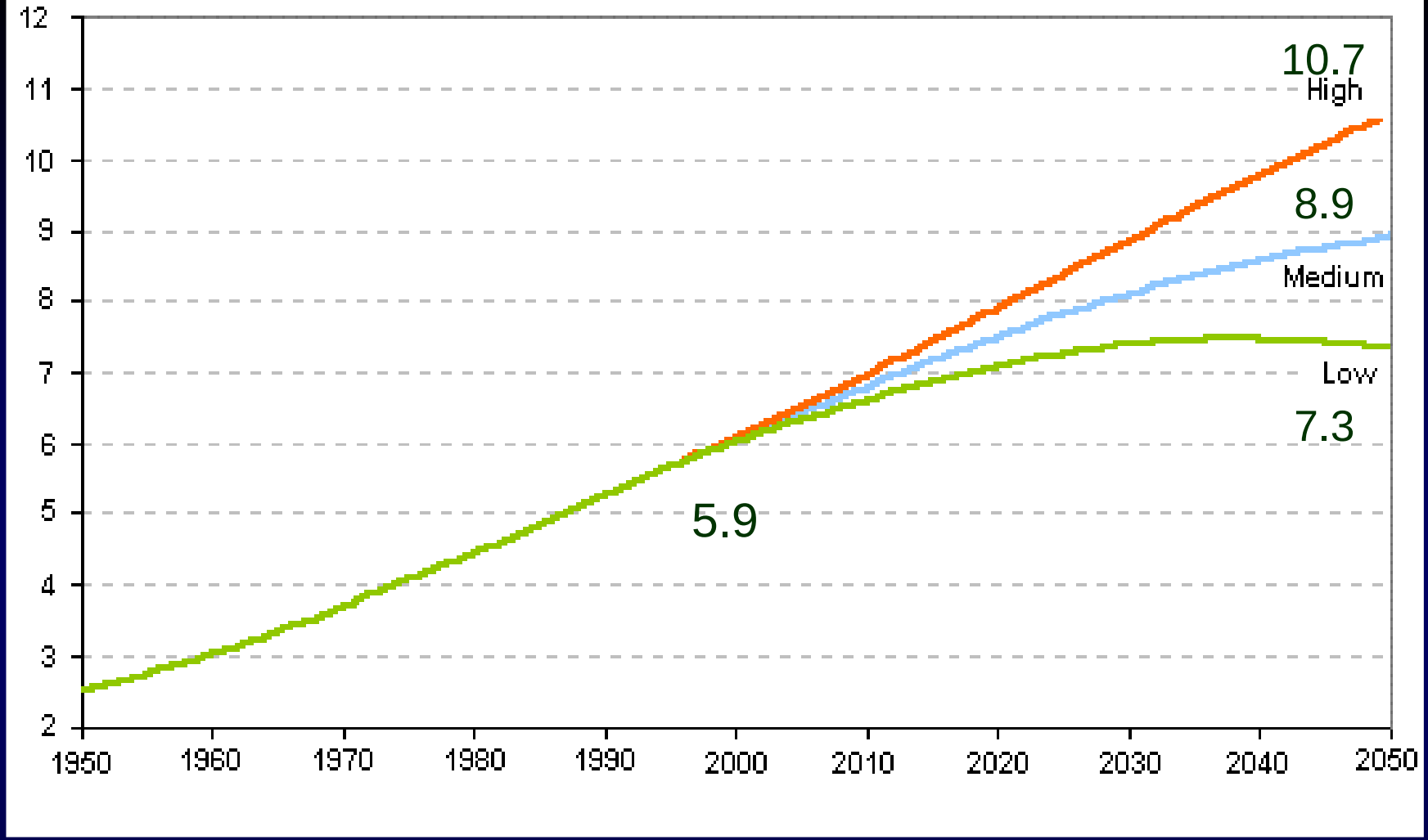
Projected total consumption	5,500,000 mt
Projected fisheries production imported	1,700,000 mt

Ministry of Maritime Affairs & Fisheries (MMAF), 1999

Prospects of Korean Aquaculture

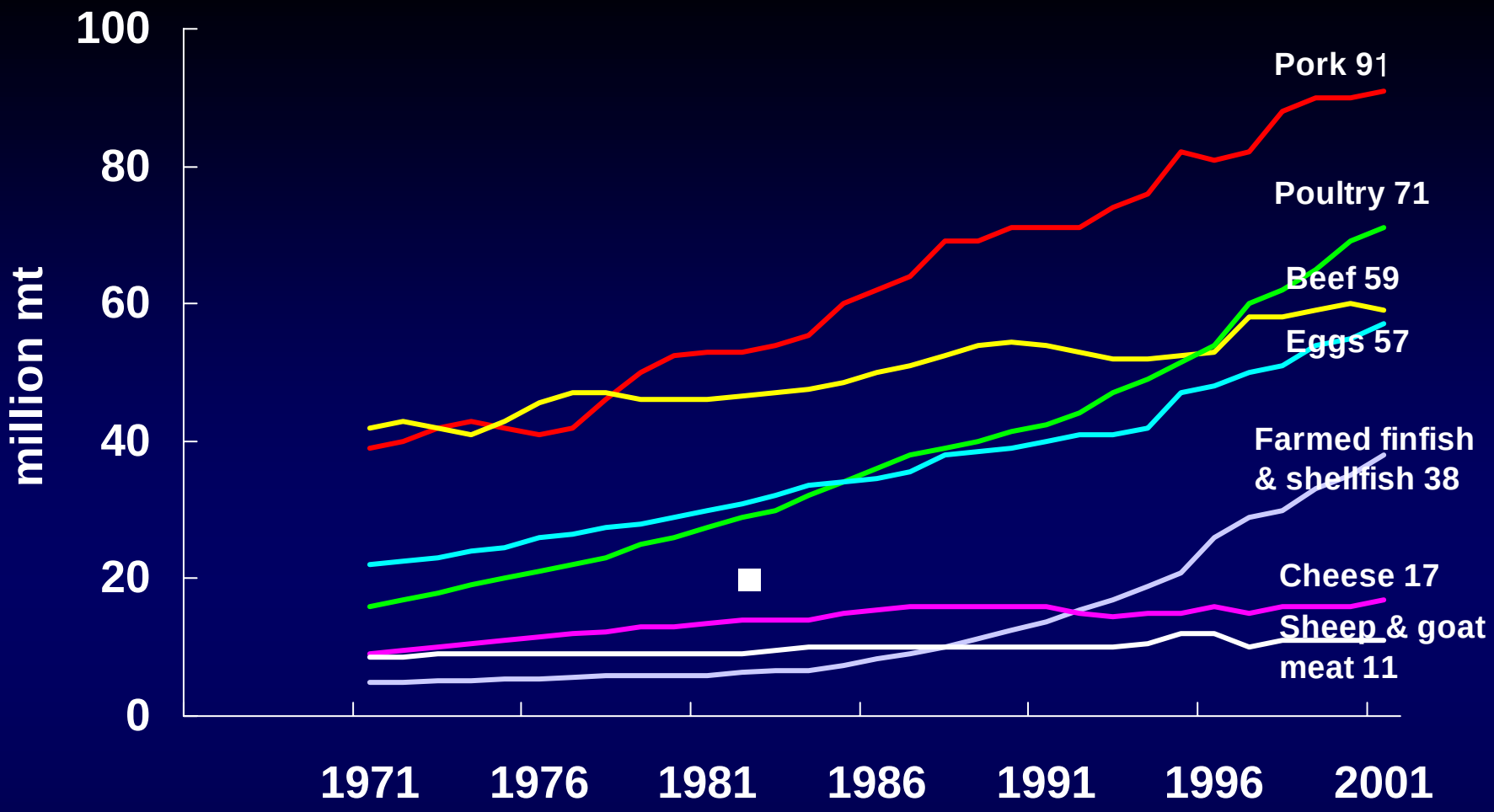
	1977	1987	1997	Targets by 2010
Marine aquaculture	491,137	866,063	1,105,134	1,988,784
Finfish	-	1,773	39,121	863,199(?6 ?22)
Crustacean	99	201	1,537	11,753 (?7 ?7.65)
Mollusc	254,796	465,989	326,633	465,989(?7)
Seaweed	236,242	398,100	647,843	647,843(?7)
Freshwater aquaculture	2,013	9,505	24,856	66,625
Finfish	691	8,264	24,951	64,306(?7 ?2.6)
Crustacean	-	-	39	1,000(Hope)
Mollusc & Algae	1,319	1,241	226	1,319 (?7)
Total	493,150	875,568	1,039,990	2,055,409(Hope)

II. Status and Prospects of World Aquaculture



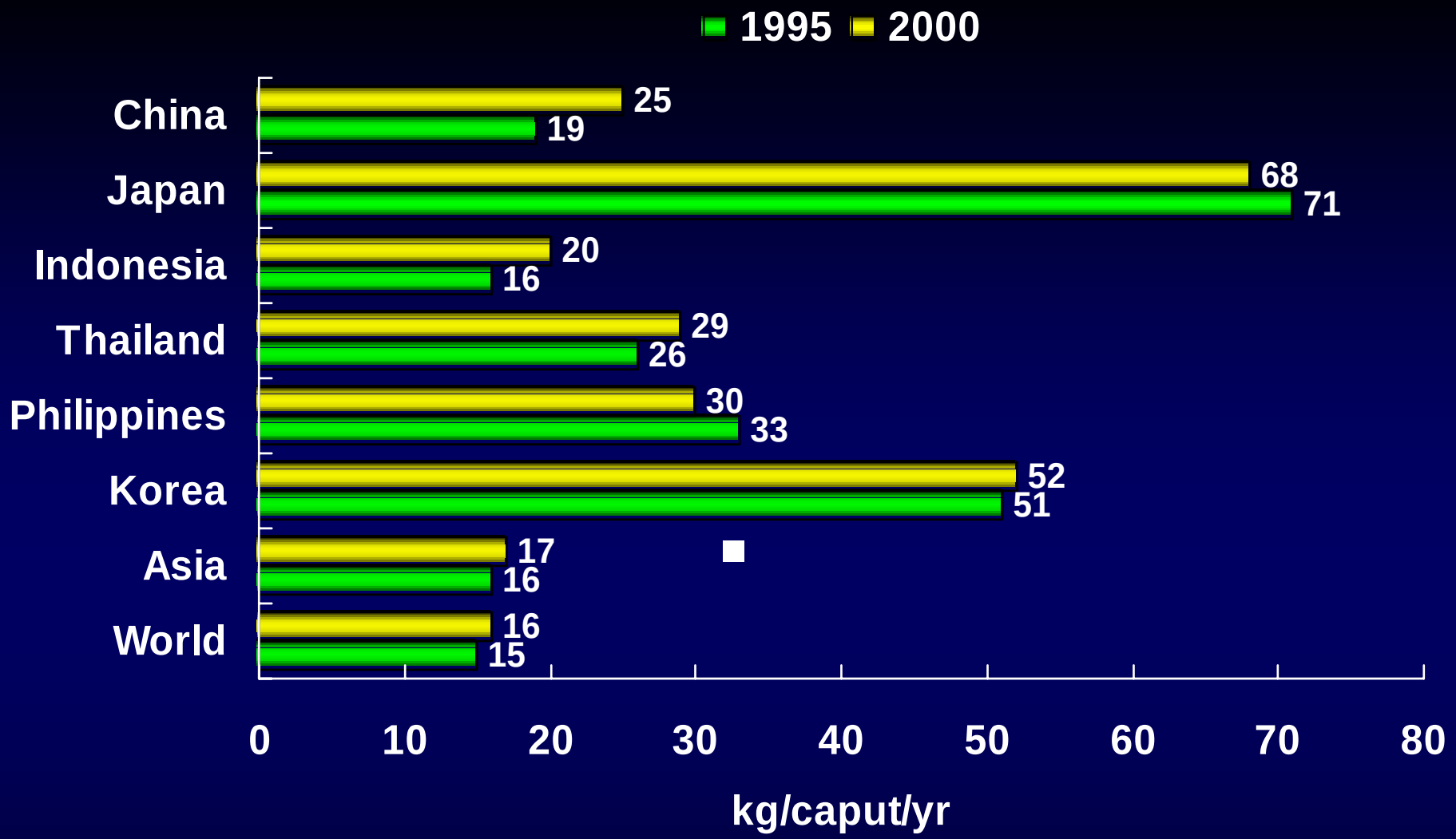
Source: UN 1998 World Population Prospects Revision

World population size: past estimates and medium-, high-, and low fertility variants, 1950-2050 (billions)



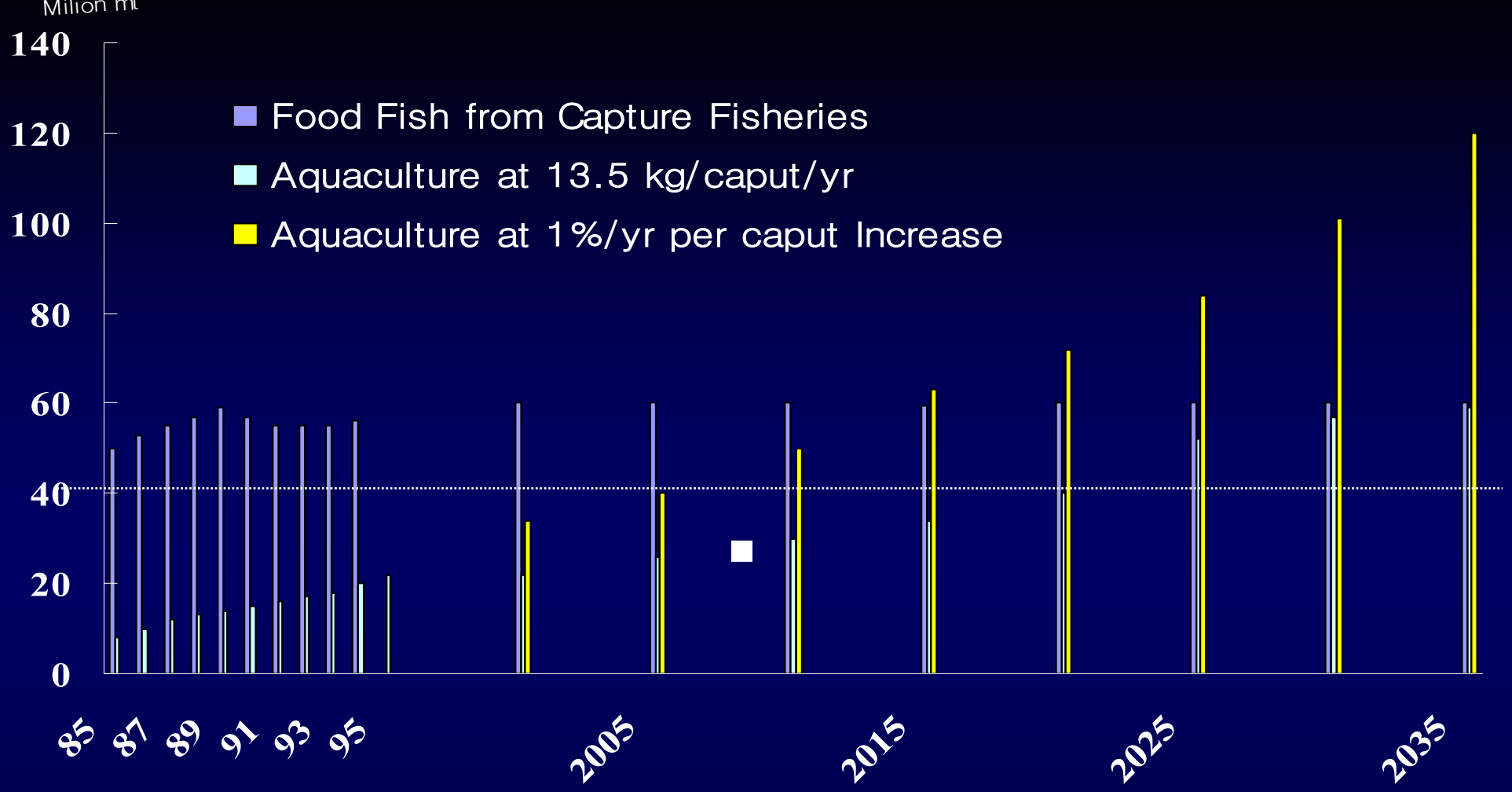
Source: FAO FISHSTAT plus statistic database (2000)

Global farmed terrestrial and aquatic meat production 1971-2001



Source: FAO FISHSTAT plus statistic database (2003)

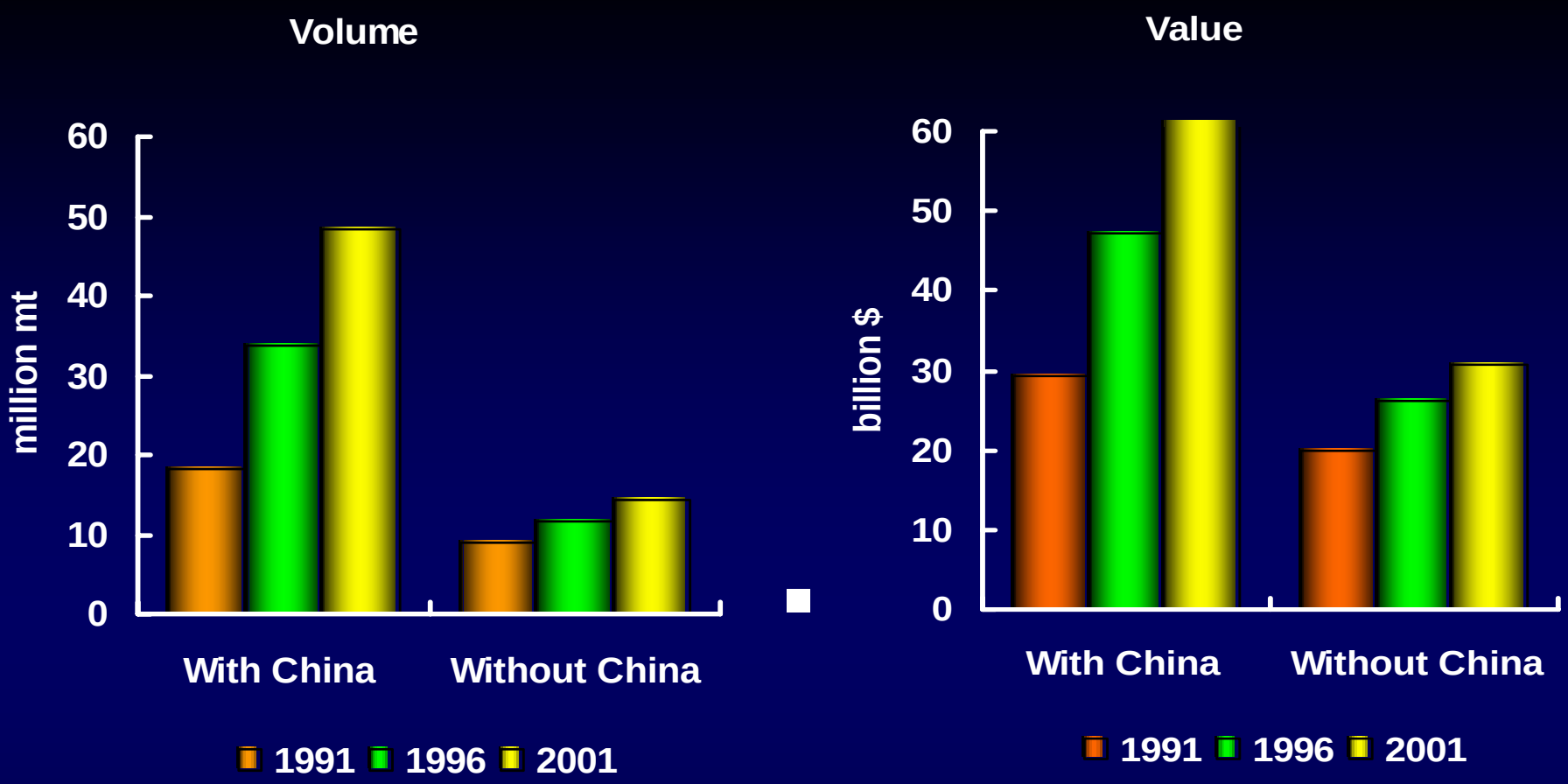
World top producers of per caput seafood consumption (2000)



Source: FAO FISHSTAT plus statistic database (1998)

Projected requirement for aquaculture production

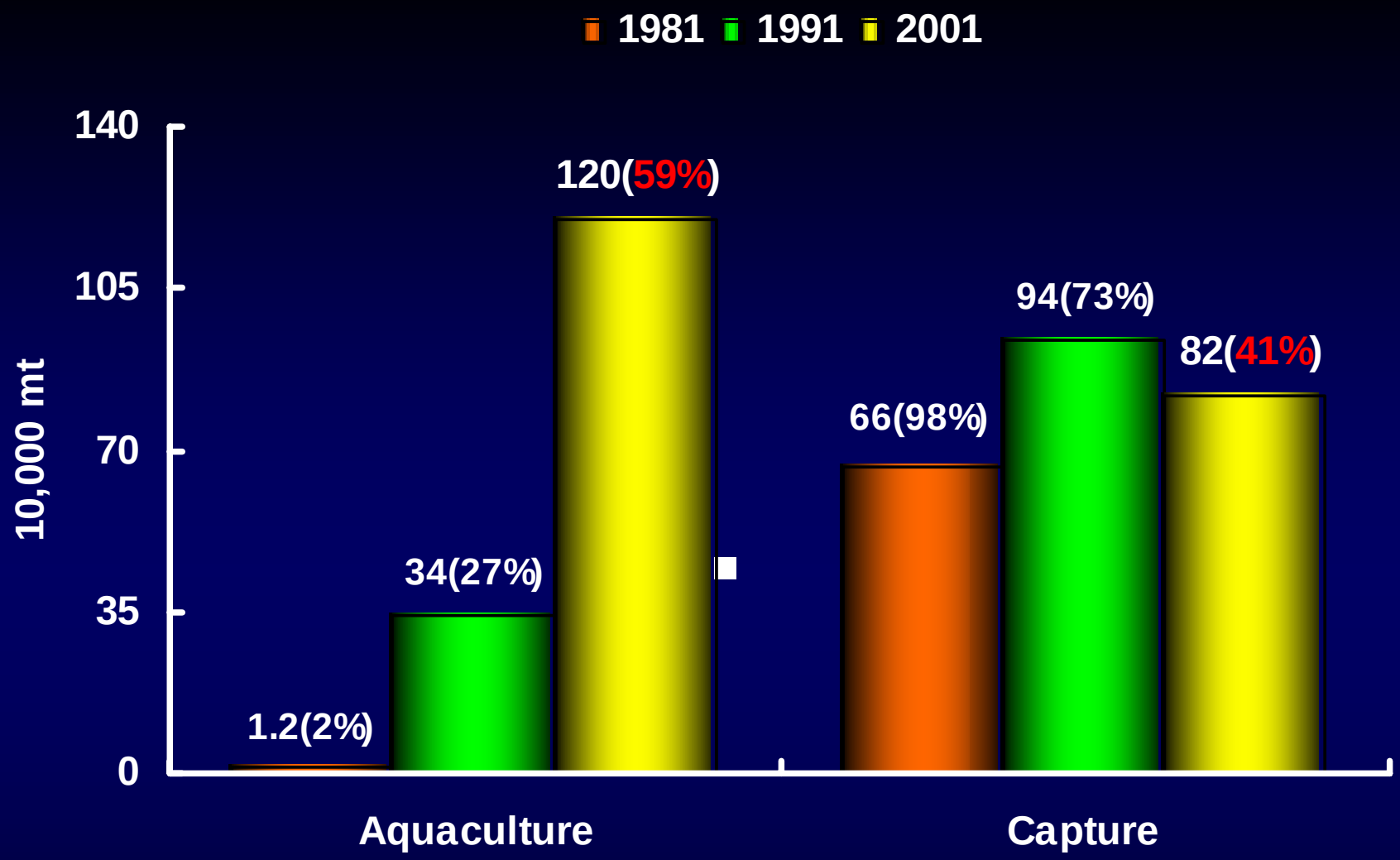
- **Trend of increasing consumption of main seafood including fish, crustaceans, & molluscs**
- **Present seafood mainly from capture fisheries**
  - ⇒ **level off at 60 million mt per year (Bai, 1999)**
- **The Requirement of Aquaculture Production**
  - ⇒ **Present consumption level : 13.5kg /person/year**
  - **- 2000 : 23. 1 million mt**
  - **- 2010 : 34.9 million mt**
  - **- 2025 : 52 million mt**
  - **- 2035 : 61.7 million mt**
  - **- 2035 : 120 million mt (New, 1997)**
  - **※If consumption increase 1 % per year**



Note: including fish, crustacean, mollusc and seaweeds

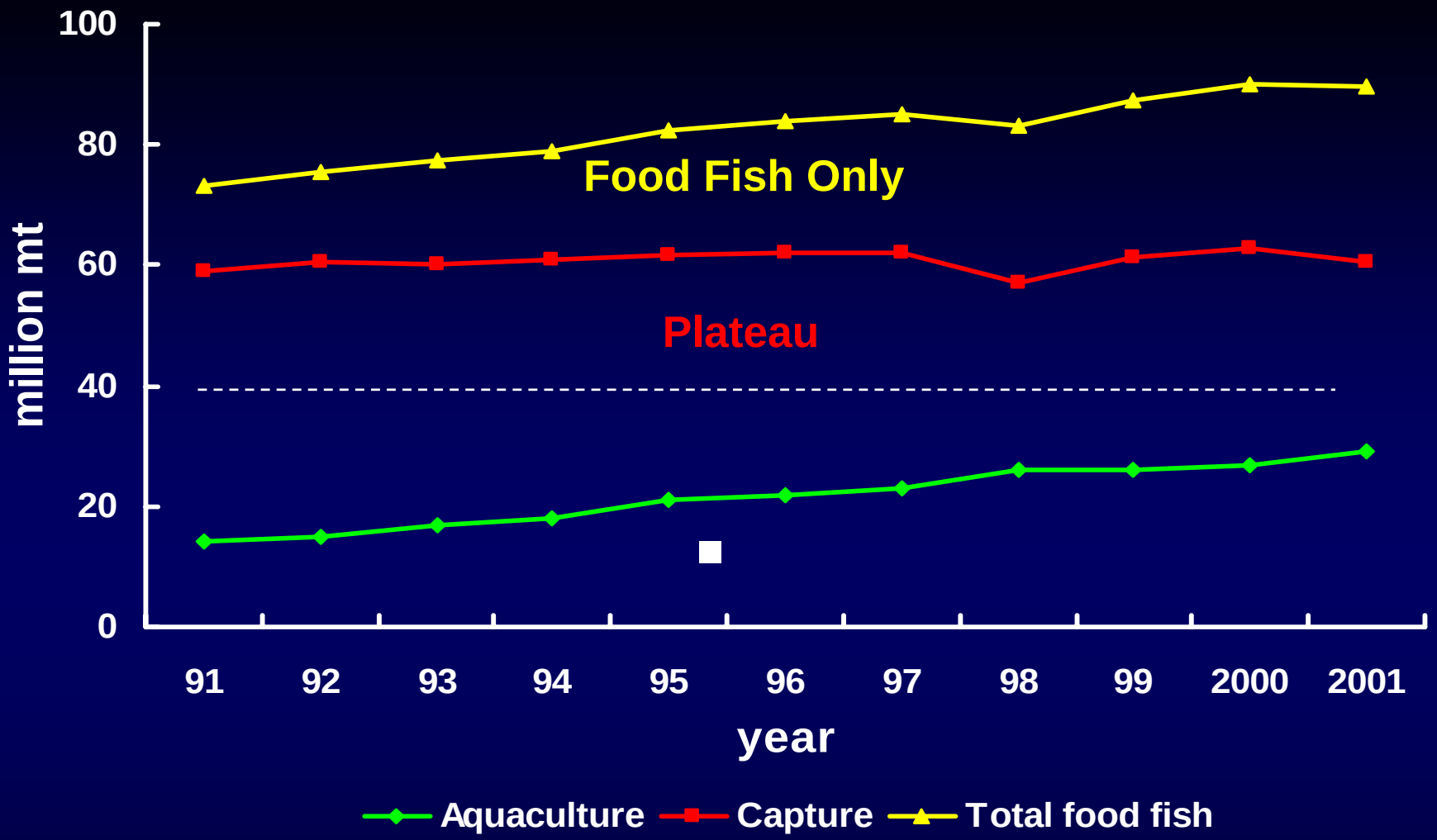
Source: FAO FISHSTAT plus statistic database (2003)

Global aquaculture production



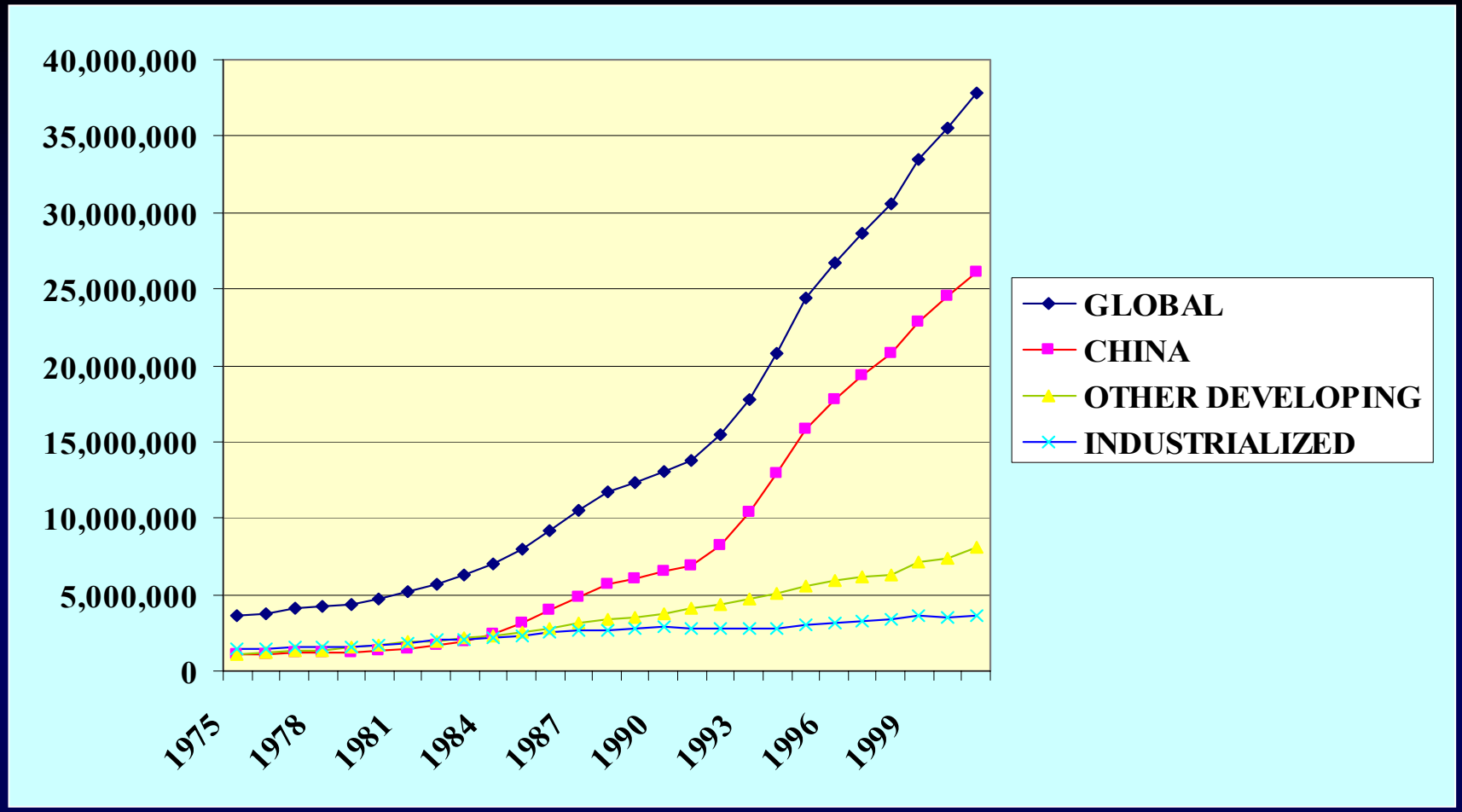
Source: FAO FISHSTAT plus statistic database (2003)

Salmon production



Source: FAO FISHSTAT plus statistic database (2003)

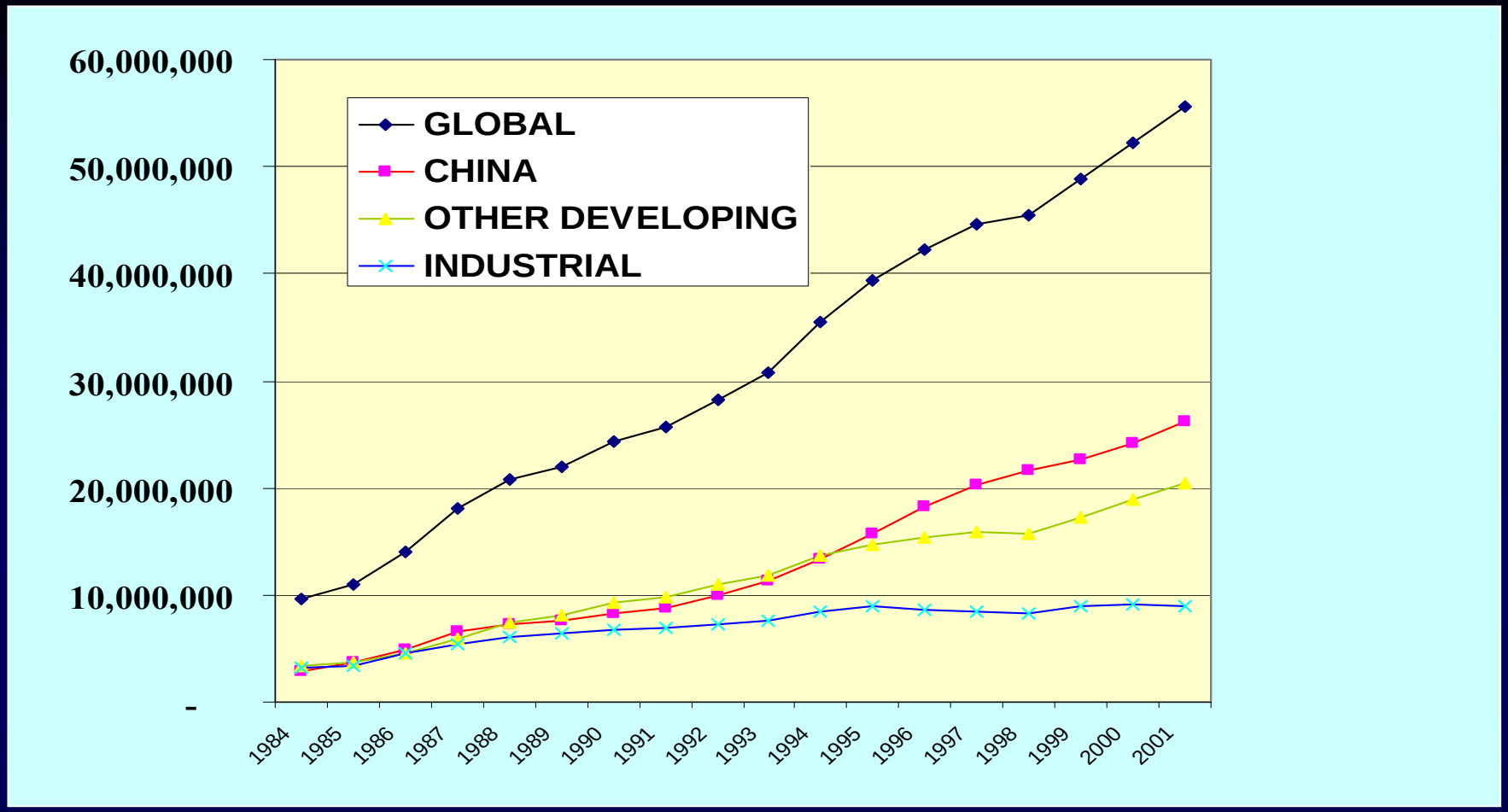
Global production trends



Note: including fish, crustacean and mollusc without seaweeds

Source: FAO FISHSTAT plus statistic database (2003)

Production of foodfish by aquaculture 1975-2001



Source: FAO FISHSTAT plus statistic database (2003)

Value of foodfish produced by aquaculture (us$ thousand)

Top Aquaculture Producers by Volume (excluding seaweeds)

Country	Production (X1000 mt) & rank		
	1981	1991	2001
China	1,473 (1)	6,881 (1)	26,050(1)
India	407 (3)	1,225 (2)	2,203(2)
Indonesia	222 (7)	518 (4)	864(3)
Japan	570 (2)	803 (3)	802(4)
Thailand	129 (10)	353 (7)	724(5)
Bangladesh	97 (12)	211 (11)	687(6)
Chile	1 (15)	48 (15)	566(7)
Viet nam	103 (11)	165(12)	519(8)
Norway	13 (14)	160(13)	512(9)
USA	230 (6)	364(6)	460(10)
Philippines	269 (5)	409(5)	435(11)
Egypt	21 (13)	62(14)	343(12)
Spain	215 (8)	225(10)	313(13)
Taiwan	191 (9)		297(14)
Korea, Rep.	322 (4)	342(8)	294(15)
Others	982		2,781
Total	6,884	13,732	37,851

Source: FAO FISHSTAT plus statistic database (2003)

Top Aquaculture Producers by Volume in 2001*

Country	Production 1000mt (rank)
China	34,210(1)
India	2,203(2)
Japan	1,314(3)
Philippines	1,220(4)
Indonesia	1,077(5)
Thailand	724(6)
Bangladesh	687(7)
Korea, Rep.	668(8)
Chile	632(9)
Viet Nam	535(10)
Norway	512(11)
USA	461(12)
Others	4,172
Total	48,414

Source: FAO FISHSTAT plus statistic database (2003)

*including seaweeds

III. Sustainable and Sound Aquaculture

Limitations & Problems of World Aquaculture

- Limiting supplementation of fish meal
  : The cost of production fish → increase
- Water pollution caused by excess use of fish meal
- Water pollution and economic loss by difficulty of aquafarm Management
- Absence of development of environment monitoring technology
- Absence of disease control technology

Solutions of World Aquaculture Problems

- Development of alternate sources of high-quality proteins to
- replace high-cost fish meal must be identified
- Development of low pollution formulated diets
- Development of environment friendly recirculating system
- Development of environment monitoring technology
- Development of disease control technology

Environmentally friendly sound auqauculture

Importance of Development of Aquatic Formulated diets

- Charged 30-60% of aquaculture production cost
- Increase aquaculture industry productivity
- Strengthen the competitive power of aquaculture industry
- food industrialization of aquaculture as nation’s key industry

Problems of Raw fish and Moist pellet

- Concern of water environment pollution when supply diet

  ⇒ Feed waste amount is higher than EP diet

- Easy to be infected because non-sterilized feeds
- Limiting supplementation of raw fish
- Nutrient Imbalance

  ⇒ difficult to culture fish in nutritional method

Merits of Formulated Practical feed

- Possible to produce nutrient balanced feeds
- Possible to set up auto feeder system

  ⇒ easy to manage and supply feeds, reduce labor cost
- Easy to store (possible store for 3 months at room temperature)
- Planned production possible
- healthy culture, reduce the possible of disease infection

2,250 mt moist pellet* (MP)

Intake* : 1,463 mt
(65% of total MP)

Feed waste* : 787 mt
(35% of total MP)

Faeces* : 293 mt
(20% of total intake)

Production** : 1,000 mt

Total waste* : 1,080 mt

*Moist pellet, feed waste, faces & total waste are on 36% water basis
**Atlantic salmon are on 68% water basis

Therefore, for this moist pellet the production:waste ratio = 1:1.08

1,200 mt extruded pellet* (EP)

Intake* : 1,164 mt
(97% of total EP)

Feed waste* : 36 mt
(3% of total EP)

Faeces* : 233 mt
(20% of intake)

Total waste* : 269 mt

Production** : 1,000 mt

Total waste : 368 mt
(36% water basis)

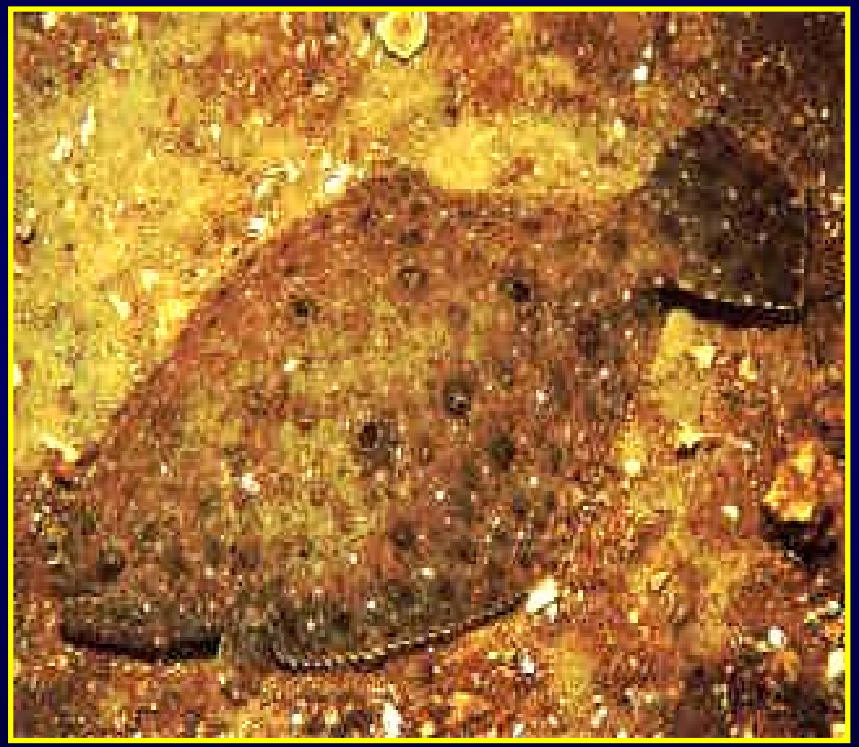
*Extruded pellet, feed waste, faces & total waste are on 9% water basis
**Atlantic salmon are on 68% water basis

Therefore, for this extruded pellet the production:waste ratio = 1:0.269 or 1:0.368 (36% water basis)

IV. Development of the low pollution fish feeds

Olive flounder (*Paralichthys olivaceus*)

- One of the important mariculture species in Korea
- High growth rate and feed efficiency
- High tolerance to water temperature change
- Establishment of the seed -ling production method

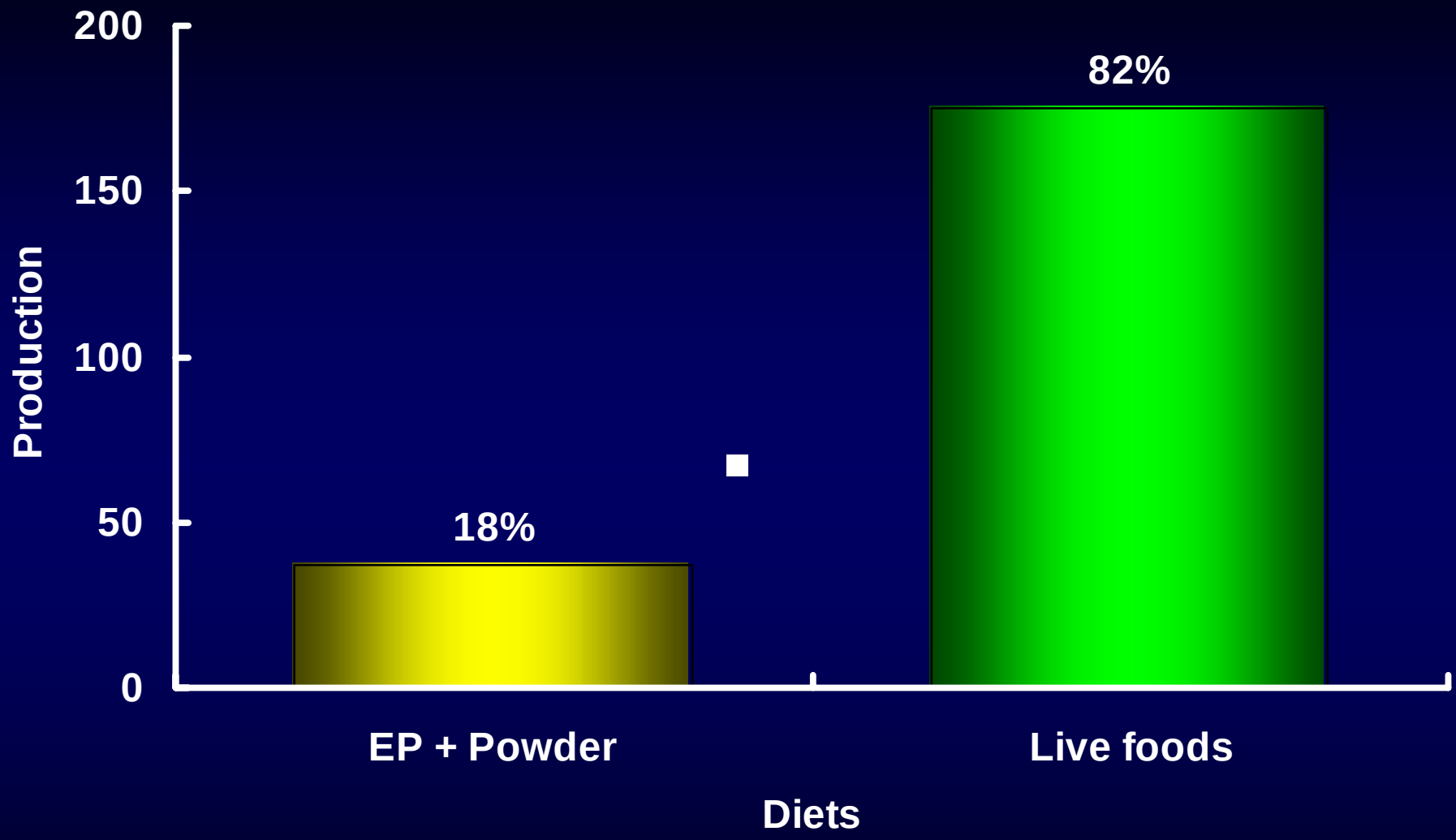


Status of olive flounder aquaculture in Korea

- **Present used diets** : the raw-fish based moist pellets (MP) diets
- **Current use of raw fish** : approx. 170, 000 mt
- **Problems of MP** : Disease outbreak
  Water pollution
  High production cost

To solve these problems

Development of the practical & low pollution diets



Current Production of EP+Powder and Live foods

Development of the low pollution feeds

- **Strategy to develop the low-pollution feeds**
  - ⇨ Selection of feed ingredients with high P & N bioavailability and absorption
  - ⇨ Reduction of P levels in feeds without affecting growth, feed efficiency and normal health condition in fish etc.
  - ⇨ Development of the low pollution feeds

- **Some of the experiments to develop the low pollution feeds at the FFNRC as the current national project**

Development of the practical & low pollution diets in olive flounder

Practical Diets

- ✓ 1. Nutrient Requirements
  - ≫ Protein, P/E ratio, Vitamins, Phosphorus etc.
- ✓ 2. Fishmeal replacers
- ✓ 3. Additives

Low Pollution Diets

- ✓ 4. Enhancing Bioavailability of P in diets
  - ≫ Phytase supplementation, Availability of inorganic P sources
- ✓ 5. Selection of ingredients for the low pollution diets
  - ≫ Phosphorus retention, Protein & phosphorus digestibility etc.

Diet formulation

1. Nutrient requirements

- ✓ Exp 1. Optimum dietary protein level
- ✓ Exp 2. Optimum dietary protein to energy ratio
- ✓ Exp 3. The Dietary vitamin C requirement
- ✓ Exp 4. Effects of vitamin E deficiency on dietary vitamin C requirement
- ✓ Exp 5. Optimum dietary choline requirement
- ✓ Exp 6. The dietary phosphorus requirement

2. Fishmeal replacers

- ✓Exp. 1 Soybean meal
- ✓Exp. 2 Other protein sources

3. Additives

- ✓ Exp 1. Effects of dietary β-1,3 glucan on growth and immuno response
- ✓ Exp 2. Effects of dietary recombinant bovine and human growth hormone levels

4. Enhancing bioavailability of P in diets

- ✓ Exp 1. The effects of the dietary microbial phytase supplementation on growth performance and bioavailability of phosphorus
- ✓ Exp 2. Availibility of various inorganic phosphorus sources

5. Selection of ingredients for the low pollution diets

- ✓ Exp 1. Effects of the dietary protein sources on growth and phosphorus retention efficiency
- ✓ Exp 2. Apparent protein and phosphorus digestibilities of the dietary protein sources

V. Challenges for 21st Century's Aquaculture

1. Environmentally sound aquaculture
2. Economically sound aquaculture & Improvements in technology
3. Improvements in the marketing system
4. Public image of aquaculture

1. Environmentally sound aquaculture

- Development of the environmentally friendly diets
- Develop the efficient recirculating aquaculture systems
- Develop the poly-culture model (agriculture+aquaculture)

2. Economically sound aquaculture & Improvements in technology

- Select the Target Fish Species
- Standardization and Automatization of the farms

3. Improvements in the marketing system

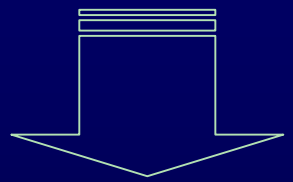
- Promotion and Maketing for the Target Species
- Inhancing Fisheries Food Processing and Marketing Standard
- Development of the Control System of Marketing

4. Public image of aquaculture

- Importance of the high quality fisheries products
- Aquaculture can be the environmentally sound food
- industry by the modern high technology

Environmentally and Economically

Sound Aquaculture



Sustainable Food Industry


Thank you!