

## TRENDS IN AQUACULTURE PRODUCTION AND NUTRIENT SUPPLY

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### Summary

Approximately 34.1 million metric tons (mmt) of farmed aquatic products were produced in 1996 or just over a quarter of the total worlds fisheries landings (capture fisheries totaling 95.7 mmt in 1996). Moreover, in terms of global food supply, aquaculture produced the equivalent of 16.3 mmt of aquatic meat products (after gutting and shelling) for direct human consumption in 1996, and is now ranked fourth in terms of global farmed meat supply after pig meat (87.1 mmt), beef and veal (53.9 mmt), and chicken meat (49.5 mmt) production.

In terms of feeding habit and nutrient supply global aquaculture production in 1996 may be conveniently divided into six basic categories, reflecting primary trophic behavior, namely:

- Photosynthetic plants: 7.7 mmt or 22.6% total production
- Filter feeding mollusks: 8.5 mmt or 24.9% total production
- Filter feeding finfishes: 4.7 mmt or 13.8% total production
- Herbivorous/omnivorous fin fishes: 9.9 mmt or 29.0% total production
- Benthophagic scavenging crustaceans: 1.1 mmt or 3.2% total production
- Carnivorous finfishes: 2.0 mmt or 5.9% total production

The paper reviews the feeding strategies currently employed by farmers for the production of the above named species groupings, and discusses the long terms

sustainability of these feeding systems in terms of future nutrient availability and cost, and the increasing global awareness concerning issues such as food safety, resource use and management, and the environment.

### 1. Global Aquaculture Production and Food Supply

Aquaculture, the farming of aquatic animals and plants, currently encompasses the production of over 212 different aquatic animal and plant species, including 122 finfish species, 46 mollusk species, 26 crustacean species, 13 aquatic plant or seaweed species, and 5 miscellaneous animal species ranging from turtles and frogs, to sea squirts (FAO Fishery Information, Data and Statistics Unit Database “AQUACULT-PC,” April 1998; FAO, 1998a).

In view of the large number and diversity of species cultivated, it is perhaps not surprising that aquaculture has emerged into the world’s fastest growing food production system. For example, between 1984 and 1996 (1996 being the latest year for which complete information was available concerning global aquaculture production prior to the compilation of this paper) the aquaculture sector has been growing at an average compound rate of 11.6% per year (see Figure 1), as compared with 3.5% per year for total terrestrial livestock meat production (see Figure 2) and 1.8% per year for total capture fisheries production (see Figure 1). Moreover, aquaculture’s contribution toward total world fisheries landings has more than doubled since 1984, increasing from 11.4% of total fisheries landings (includes both capture fisheries and aquaculture) in 1984 to 26.3% of total landings by weight in 1996; total fisheries landings in 1996 being 129.8 mmt and aquaculture contributing 16.9% of total finfish landings (72.5% of total freshwater finfish landings, 43.4% of total diadromous finfish landings, and 0.76% of total marine finfish landings), 17.0% of total crustacean landings (27.0% of total marine shrimp landings), 56.7% of total mollusk landings, and 87.5% of total landings of aquatic plants (see Figure 1; FAO, 1998a, 1998b).

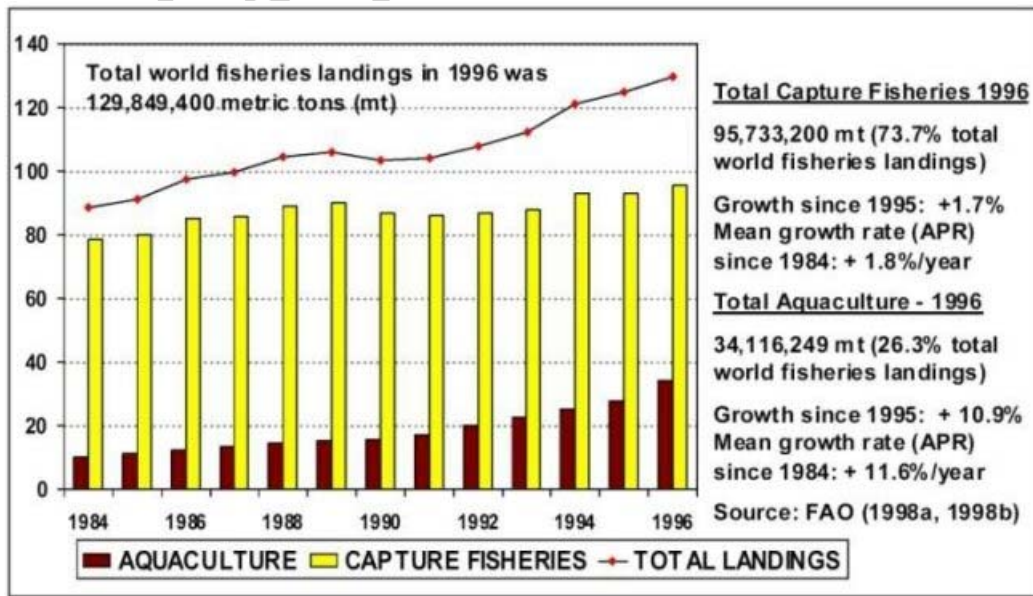


Figure 1. Contribution of aquaculture to total world fisheries landings 1984–1996.

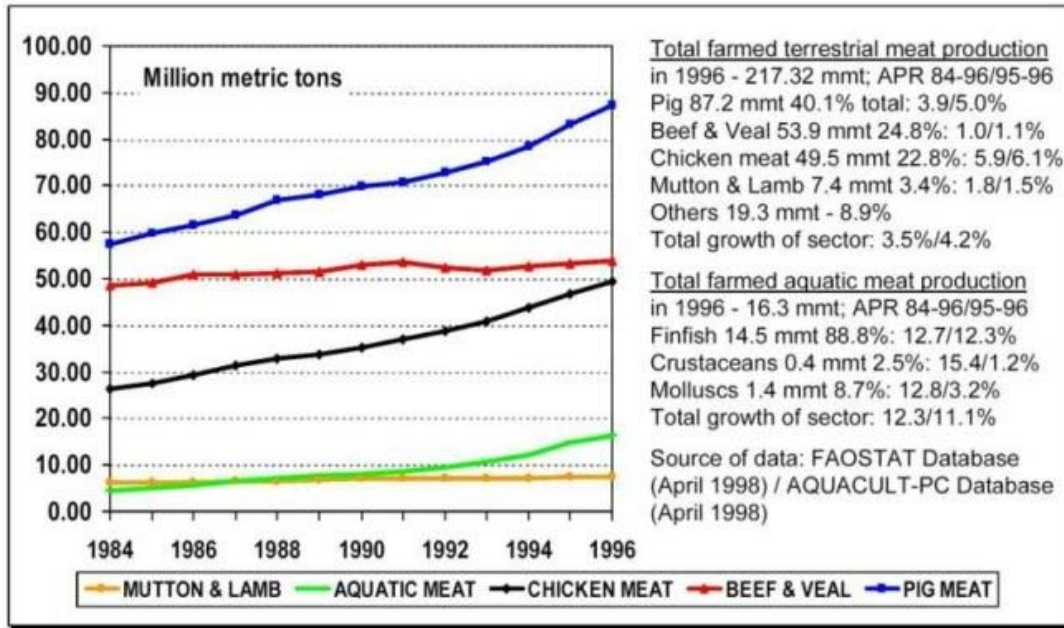


Figure 2. Total global farmed terrestrial and aquatic meat production 1984–1996.

Total global aquaculture production was estimated to be about 34.1 million metric tons (mmt; up 10.9% since 1995) and valued at US\$46.5 thousand million in 1996, with finfish constituting nearly half of total production by weight (see Figure 3). The growth of the different major specific groups over the past decade is shown in Figure 4, with most groups exhibiting double digit growth rates over the period 1984 to 1996, including finfish (12.7%/year, with production up by 12.3% since 1995), mollusks (12.8% per year, with production up by 3.2% since 1995), aquatic plants (8.4% per year, with production up by 19.2% since 1995), and crustaceans (15.4% per year, with production up by 1.2% since 1995; see Figure 4).

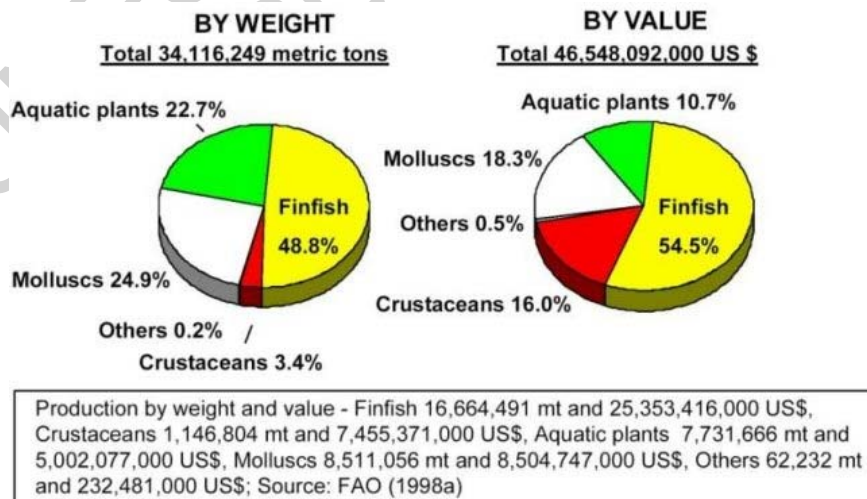


Figure 3. Total world aquaculture production in 1996.

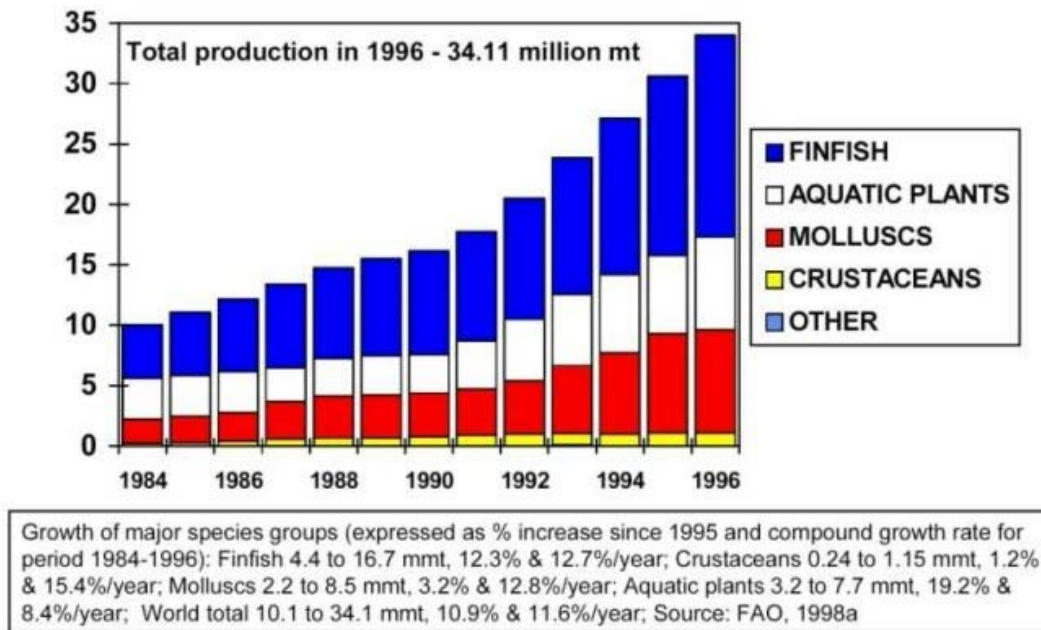


Figure 4. Total world aquaculture production by major species groups 1984–1996. Provisional estimates for total finfish and shellfish aquaculture production in 1997 (excluding aquatic plants) have been reported as 28.27 mmt (up 7.1% from 26.38 mmt in 1996), with capture fisheries finfish and shellfish production as 93.73 mmt (down 0.9% from 94.62 mmt in 1996; Maurizio Perotti, Fishery Statistician, FAO Fishery Information, Data and Statistics Unit—personal communication, October 1998).

In terms of per capita “food fish” supply from aquaculture (i.e. the production of farmed aquatic finfish and shellfish on a whole live weight basis, and excluding farmed aquatic plants) global production has increased by 213% since 1984 from 1.46 kg to 4.57 kg in 1996, with supply growing at an average rate of 10.9% per year. By contrast, per caput food fish supply from capture fisheries has remained relatively static, increasing from 10.8 kg in 1984 to 11.03 kg in 1996 at an average rate of 1.8% per year or equivalent to the growth of the human population (1.75%) over the same period. On the basis of the above data over one in four “food fish” consumed by humans in 1996, from a total average per capita food fish supply of 15.6 kg is currently being supplied by aquaculture.

In terms of global “meat supply” aquaculture produced the equivalent of 16.3 mmt of aquatic meat products after gutting/shelling for direct human consumption in 1996 (see Figure 5; calculations based on using average conversion ratios of live weight equivalents to potential edible meat of 1.15 for finfish (gutted, head on), 2.80 for crustaceans (tails, peeled), and 6.0 for mollusks (meat). By contrast, although the total production of finfish and shellfish from capture fisheries amounted to 94.6 mmt in 1996 (FAO, 1998b), only 64.2 mmt (live weight equivalent) was available for direct human consumption as “food fish” or the equivalent of about 48 mmt of aquatic meat products after gutting and shelling. Interestingly, total aquatic meat production from both capture fisheries and aquaculture amounted to about 64.3 mmt in 1996 or just under a quarter (i.e. 22.8%) of the total world production of terrestrial and aquatic meat products (281.6 mmt in 1996); total world terrestrial meat production in 1996 being 217.3 mmt,

including 87.1 mmt of pig meat, 53.9 mmt of beef and veal, 49.5 mmt of chicken meat, and 7.4 mmt of mutton and lamb (see Figure 5). On the basis of per capita “aquatic meat” supply from aquaculture, production has increased by 198% since 1984 from 0.95 kg to 2.83 kg in 1996, with per capita supply increasing at an average rate of 12.3% per year since 1984 (as compared with only 3.5% for livestock meat production, and 1.8% for capture fisheries production).

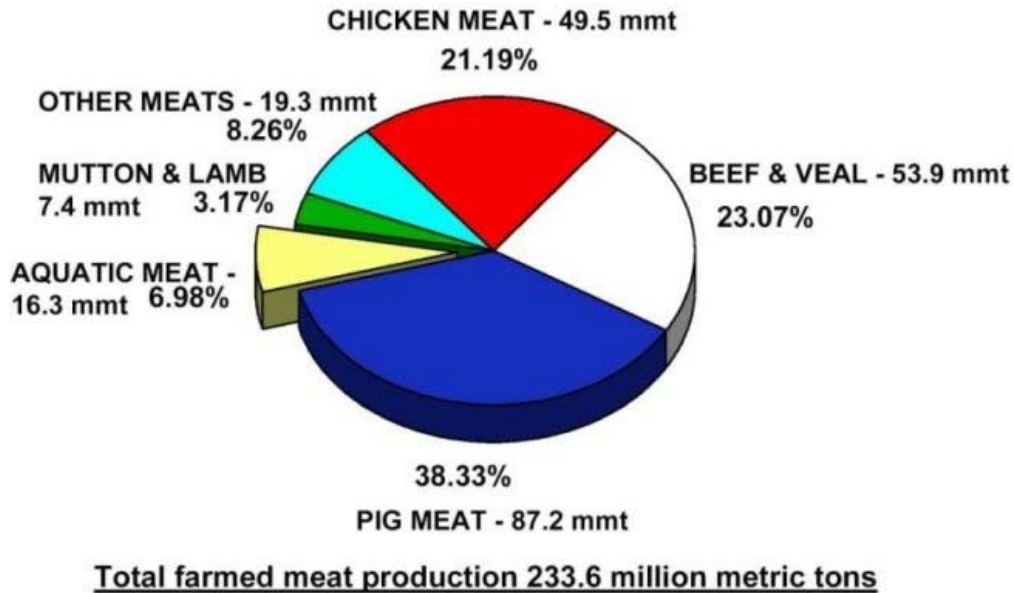


Figure 5. Total world farmed aquatic and terrestrial meat production in 1996 (source: faostat/aquastat-pc databases, 1998).

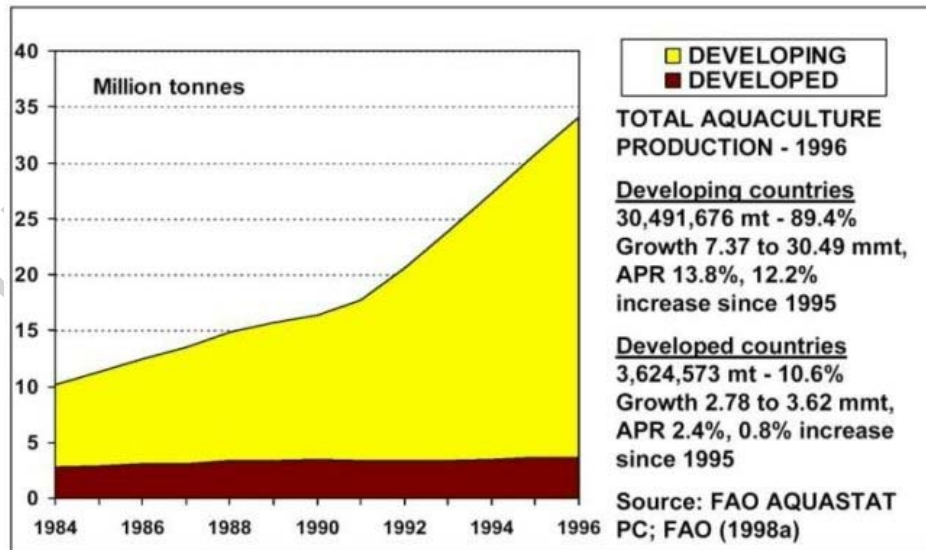


Figure 6. Total world aquaculture production by major economic country groupings.

Country	Production (Metric tons) a/	Production (% Total world, S) b/	Production (per capita, kg) c/	Growth (APR 84-96, %/yr) d/	Growth (Increase 95-96, %) e/	Total value (US \$ 1,000)	Unit value (US \$/kg)
<b>01. CHINA</b>	23 134 520	67.8	19.1	+17.8	+15.6	21 153 959	0.91
<b>02. INDIA</b>	1 768 422	73.0	1.9	+12.0	+4.9	1 979 604	1.12
<b>03. JAPAN</b>	1 349 405	76.9	10.8	+1.0	-2.9	5 012 316	3.71
<b>04. PHILIPPINES</b>	974 065	79.8	14.0	+6.7	+6.1	1 257 558	1.29
<b>05. KOREA, REP</b>	896 998	82.4	19.8	+2.6	-11.8	981 534	1.09
<b>06. INDONESIA</b>	780 130	84.7	3.9	+8.1	+5.8	2 030 997	2.60
<b>07. THAILAND</b>	509 656	86.2	8.7	+14.8	-8.0	1 836 725	3.60
<b>08. KOREA, DPRP</b>	456 000	87.5	20.3	-3.3	+2.4	436 700	0.96
<b>09. USA</b>	393 331	88.7	1.5	+1.7	-4.9	736 423	1.87
<b>10. BANGLADESH</b>	390 088	89.8	3.2	+11.6	+21.3	806 451	2.07
<b>11. NORWAY</b>	324 543	90.8	74.7	+25.8	+16.9	1 026 421	3.16
<b>12. CHILE</b>	323 115	91.7	22.4	+39.0	+56.6	829 187	2.57
<b>13. FRANCE</b>	285 721	92.6	4.9	+3.6	+1.7	582 729	2.04
<b>14. TAIWAN, P.O.C</b>	272 209	93.4	12.7	+1.0	-5.0	1 181 687	4.34
<b>15. SPAIN</b>	233 833	94.1	5.9	-0.5	+3.3	286 858	1.23
<b>16. ITALY</b>	206 515	94.7	3.6	+7.1	-8.2	408 100	1.98
<b>17. VIET NAM</b>	196 000	95.2	2.6	+4.6	-10.7	517 800	2.64
<b>18. UK</b>	109 901	95.6	1.9	+18.1	+17.1	268 630	2.44
<b>19. ECUADOR</b>	109 085	95.9	9.3	+11.3	+2.2	649 947	5.96
<b>20. MALAYSIA</b>	109 002	96.2	5.3	+4.4	-17.9	159 954	1.47

a/ Total aquaculture production (includes finfish, crustaceans, mollusks, miscellaneous aquatic animals/products, and aquatic plants); b/ Accumulative total as % total world aquaculture production; c/ Per capita total aquaculture production; d/ Annual Percent Growth Rate in production by weight between 1984 and 1996; e/ Percent change in production by weight between 1995 and 1996; Source: FAO (1998a).

Table 1. Top twenty aquaculture producers in 1996.

By economic country grouping approximately 89.4% and 81.6% of total world aquaculture production in 1996 was produced within developing countries (30.49 mmt) and in particular within Low-Income Food Deficit Countries (27.85 mmt; LIFDCs having an average per capita income <US\$1505 per annum in 1996), respectively. Moreover, whereas the developing country share of aquaculture production has increased from 72.6% (7.37 mmt) of total aquaculture production in 1984 to 89.4% (30.49 mmt) in 1996, the share of production from developed countries has decreased from 27.4% (2.78 mmt) in 1984 to 10.6% (3.62 mmt) in 1996 (Figure 6). By contrast, although 53.5% of total terrestrial meat production was produced within developing countries in 1996 (mean growth rate of 7.10% per year from 1984 to 1996 as compared with a mean growth rate of 0.65% per year for developed countries), only 38.2% was produced within LIFDCs (mean growth rate 9.0% per year since 1984). Aquaculture production within LIFDCs has been growing over 6 times faster (14.9% per year since 1984) than within developed countries (2.4% per year since 1984), with aquaculture production within developing countries displaying an average growth rate of 13.8% per year between 1984 and 1996.

By region, Asia produced over 91.1% of total aquaculture production by weight in 1996 (83.5% by value; production up by 11.2% since 1995), followed by Europe (4.66%; production up by 6.8% since 1995), North America (1.77%; production up by 0.1% since 1995), South America (1.55%; production up by 32.8% since 1995), Africa (0.35%; production up by 14.5% since 1995), the Former USSR area (0.31%; production down by 19.2% since 1995), and Oceania (0.29%; production up by 6.9% since 1995; FAO, 1998a).

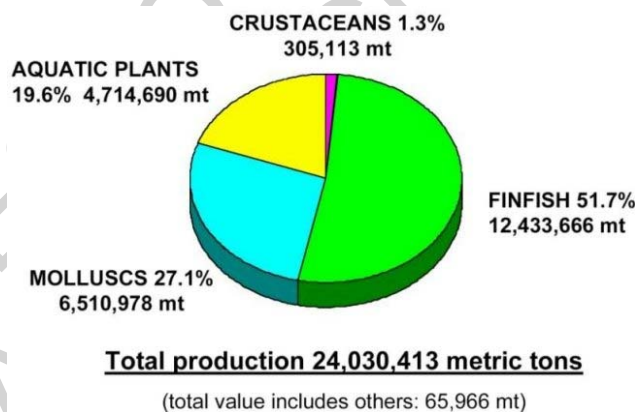


Figure 7. Total reported aquaculture production in China in 1997.

By country the top ten aquaculture producers in the world in 1996 were: China (23.1 mmt, 67.8% world total), India (1.77 mmt, 5.2%), Japan (1.35 mmt, 4.0%), Philippines (0.97 mmt, 2.9%), Korea Republic (0.90 mmt, 2.6%), Indonesia (0.78 mmt, 2.3%), Thailand (0.51 mmt, 1.5%), Korea DPRP (0.45 mmt, 1.3%), USA (0.39 mmt, 1.2%), and Bangladesh (0.39 mmt, 1.1%); these ten countries accounting for about 90% of total global aquaculture production (see Table 1). More recent aquaculture production data for China report total aquaculture production in 1997 as 24.0 mmt (Figure 7, up by 8.2% from a revised 1996 production of 22.2 mmt; Maurizio Perotti, Fishery Statistician, FAO Fishery Information, Data and Statistics Unit—personal communication, October

1998), with aquaculture supplying over half (i.e. 60.2%) of total Chinese fisheries landings of 39.9 mmt in 1997 (Figure 8). Moreover, in terms of meat production, total Chinese fisheries landings produced the equivalent of 22.3 mmt of aquatic meat products for human consumption in 1997 (aquaculture: 12.0 mmt, capture fisheries 10.3 mmt), as compared with 55.5 mmt for total terrestrial meat products (see Figure 9).

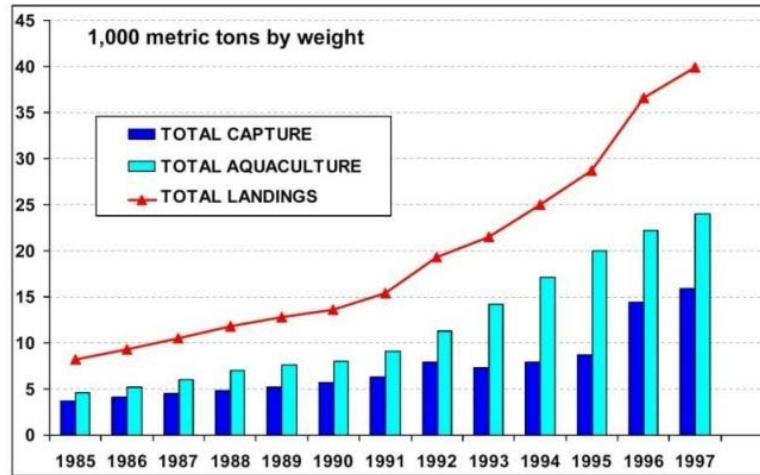
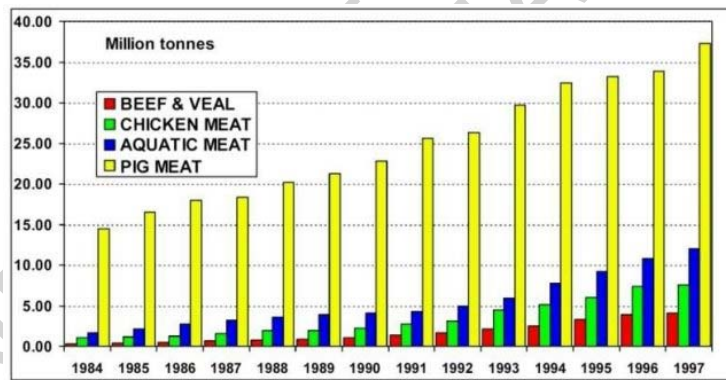


Figure 8. Time series of contribution of aquaculture toward total fisheries landings in China.



Total terrestrial meat production in 1997 - 55,493,250 mt; Pig meat 37.27 mmt (58.1%), Chicken meat 7.56 mmt (13.6%), Beef & Veal 4.10 mmt (7.4%), Duck meat 1.72 mmt (3.1%), Goose meat 1.58 mmt (2.8%), Mutton & Lamb 1.20 mmt (2.2%); Total farmed aquatic meat production in 1997 - 12,006,014 mt; Finfish 10.81mmt (90.1%), Molluscs 1.08 mmt (9.0%), Crustaceans 0.11 mmt (0.9%)

Source: FAOSTAT/AQUASTAT-PC Databases (November 1998)

Figure 9. Total farmed terrestrial and aquatic meat production in China 1984–1997.

By environment approximately 45.7% of aquaculture production was produced from inland waters in 1996, with production increasing from 4.2 mmt in 1984 (41.8% of total aquaculture production) to 15.6 mmt in 1996, with production increasing at an average rate of 12.6% per year since 1984; the bulk of production being in the form of freshwater finfish species. By contrast, approximately 54.3% of aquaculture production was produced within marine waters in 1996, with production increasing from 5.9 mmt in 1984 (58.2% of total aquaculture production) to 18.5 mmt in 1996, with production increasing at an average rate of 10.9% per year since 1984; the bulk of production being in the form of marine mollusks, aquatic plants (seaweeds), and marine crustaceans



(FAO Fishery Information, Data and Statistics Unit Database “AQUACULT-PC,” April 1998; FAO, 1998a).

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### **Biographical Sketches**

**Dr A. G. J. Tacon**, a British National, was born on 15 March 1952 in Plymouth, England. Graduating in 1973 with a Bachelor of Science (B.Sc) in Zoology and Botany from the University of London (Westfield College), Dr Tacon then went on to obtain a Doctor of Philosophy (PhD, 1978) in applied finfish nutrition at the Department of Zoology, University College, Cardiff (Wales); thesis title - The use of activated sludge as a supplementary protein source in the diet of rainbow trout. From 1976 to 1980 Dr Tacon was employed as Lecturer in Nutrition within the Biological Sciences Department of the University of Aston in Birmingham (England), and from 1980 to 1984 was employed as a Senior Research Fellow in applied finfish nutrition at the Institute of Aquaculture, University of Stirling (Scotland). In the summer of 1984 Dr Tacon joined the Food and Agriculture Organization of the United Nations (FAO) in Rome (Italy). Dr Tacon has undertaken numerous assignments for the organization within National, Regional and Inter-regional Aquaculture Projects, and at FAO Headquarters in his field of expertise, namely as an FAO expert in aquaculture nutrition and aqua feed technology. Dr Tacon left FAO at the end of June 1998, and served as Technical Director and Program Manager of the Aquatic Feeds and Nutrition Program at the Oceanic Institute in Hawaii (USA) until March 2001. He currently works from his home in Hawaii as an independent consultant. Dr Tacon is an editorial board member of numerous international journals dealing within aquaculture and aquatic nutrition, has over 31 in-country work experiences with FAO and other agencies in aquaculture development, and in particular concerning nutrition and feed development. Dr Tacon has published over 100 papers on aquaculture, and in particular papers on finfish and crustacean nutrition and feeding.

**Uwe Barg**, born in 1958 in Quito, Ecuador, graduated in 1988 from the Institute of Marine Sciences, University of Kiel, Germany, with a Master of Science in Fisheries Biology, Zoology and Marine Chemistry, specializing in aquaculture; thesis on ammonium excretion and oxygen consumption of turbot (*Scophthalmus maximus*) in aquaculture grow-out conditions. In 1988 he joined the Fisheries Department of the Food and Agriculture Organization of the United Nations (FAO) in Rome, Italy. As Fishery Resources Officer (Aquaculture), he covers environmental and resource use aspects in aquaculture development. He has facilitated the technical work of expert groups on a range of areas including environmental impacts of coastal aquaculture, aquatic resource management and aquaculture, use of chemicals in aquaculture, intensification of freshwater aquaculture, integration of aquaculture in coastal management, policies for sustainable shrimp culture. He has contributed to the formulation of the aquaculture provisions of the FAO Code of Conduct for Responsible Fisheries and to the FAO Technical Guidelines for Responsible Fisheries dealing with Aquaculture Development.