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White Paper

Development of an APEC Strategy on Sustainable Aquaculture

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1 Introduction

Presently, aquaculture contributes nearly half of the world's food fish, and represents the main potential to respond the growing demand for aquatic food. The current scenario for aquaculture implies high rates of expansion and technological intensification vìs-a-vìs emerging constraints and challenges associated to the following identified trends (FAO, 2006):

- intensification of aquaculture production (site availability, technological access and costs, health or environmental problems),
- diversification of species use (introduction or movements of species, environmental and sanitary effects),
- diversification of production systems and practices (seed production, infrastructure and services),
- increasing influence of markets trade and consumers (market information, quality and safety standards, ecolabelling),
- enhancing regulation and improving governance of the sector (environmental planning, specific zoning, monitoring and surveillance programs, traceability).

In 2000, The World Bank reported that the three major challenges faced by aquaculture are: economic growth, environmental stewardship and equitable distribution of benefits. The report underlined that an effective response to these challenges requires a coherent interplay of private investment and stewardship of public goods and that, in this context, two intertwined axes of intervention have been identified: good governance and the generation and dissemination of knowledge (The World Bank 2000). Good governance and the creation of an enabling environment, relates to the establishment of a policy framework addressing pertinent issues for strategy, including the following:

- Principles for use and allocation of the public domain
- A socially required balance between smallholder and large scale aquaculture
- Coherence with other policies and strategies
- Environmental sustainability
- Clear definition of the roles of the public and private sectors
- Sector leadership and coordination
- Aquaculture's fiscal regime

Therefore, beyond the initial expectations placed on aquaculture worldwide, there are concerns related to the expected environmental and social impacts of its further growth around the world. In particular, APEC Economies producing more than 90% of world aquaculture production and marketing over 58 Billion US Dollar (2005), the failure to develop a strategy for its sustainable development could result in a loss of opportunities for all of us.

In spite of substantial differences about the relative importance of aquaculture among APEC Economies, they share common issues through market ties and their need to manage this industry in a sustainable manner to ensure its stability in both, economic, environmental and social terms. The importance of these issues have been highlighted by the APEC work agenda through the Marine Resources Conservation Working Group (MRCWG), the Fisheries Working Group (FWG) and other related working groups. In this context, the APEC TILF project MRC 01/2004T compared the environmental principles and policies used in the administration of regional aquaculture. The outcomes of this project indicated the urgent need to develop a common framework for sustainable aquaculture development. This was validated in late 2004 at the Integrated Oceans Management, Forum III, as well as, at the 5th APEC Roundtable Meeting, both focusing on the involvement of the Business/Private Sector on the Sustainability of Marine Environment.

Accordingly, the APEC Oceans Ministers met in Bali during the 2nd APEC Oceans Ministerial Meeting (AOMM2), and on this occasion, they endorsed the Bali Plan of Action which describes the activities that the working groups should develop until 2009. This Plan of Action commits the working groups to "develop an APEC strategy on sustainable aquaculture". Thus, the development of this consultancy is oriented to provide a discussed and pre-agreed document including a draft "APEC Strategy for Sustainable Aquaculture" to be discussed at the APEC Senior Officials Meeting prior to the Third APEC Oceans Ministerial Meeting. This document must include the rationale behind the concrete actions to tackle critical environmental and social issues linked to aquaculture. The proposal will identify specific tasks for the private and public sector and will be consistent and nested into the overall APEC Sustainable Framework, which has been mentioned as an objective by Leaders at their last meetings.

The ultimate objective of this APEC MRCWG 06/2007 project is the approval of an APEC Strategy on Sustainable Aquaculture at the Third Oceans Ministerial Meeting, and this consultancy must provide the background information, compile APEC members' points of view, undertake discussions and provide an advanced draft strategy to be discussed at the political level.

The objective of this document is to lay down the groundwork information for the development of an APEC strategy on sustainable aquaculture, including: a current status of aquaculture in the APEC region (section 2), a discussion on sustainability and sustainable development concepts (Section 3), the identification of a set of indicators on sustainable development related to aquaculture, a set of concept and criteria, as well as, a procedure to establish a sound strategy on sustainable aquaculture (section 4).

2 AQUACULTURE IN APEC ECONOMIES: CURRENT STATUS ON SUSTAINABILITY.

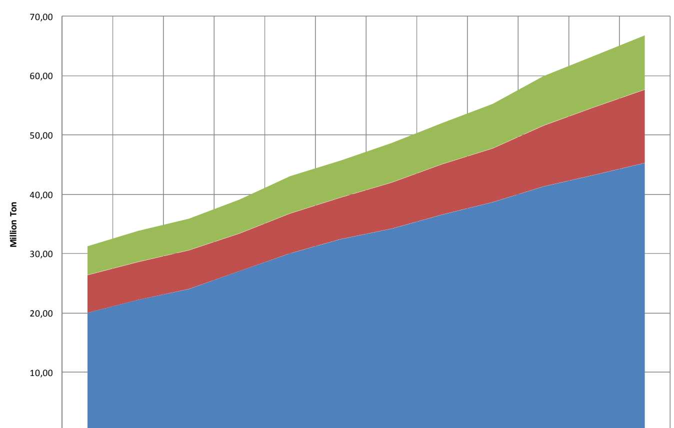
The following analysis is based upon FAO FishStat statistics[1] for the APEC economies on total production (capture fisheries plus aquaculture), aquaculture production and economy exports, imports and re-exports for the period 1995 to 2006.

2.1 Aquaculture production in APEC

2.1.1 APEC vís-a-vís de rest of the world

In 2006, aquaculture from the APEC region represented 86% (57.6 million ton) of world's aquaculture production and 79% (67.87 billion US$) of the total value. An important factor in the above is the inclusion of the PR of China in the APEC region. When aquaculture production from the PR of China is not considered for year 2006, APEC represents a 18% and 28% of the world's aquaculture volume and value respectively. As shown in Figures 1 and 2, the rest of the world provided a 14% of the world' aquaculture production and 21% of its value in 2006. Thus, PR of China produced 68% of the total production in volume and 51% of its value that same year.

Figure 1 Volume of world aquaculture production (million ton), period 1995 – 2006



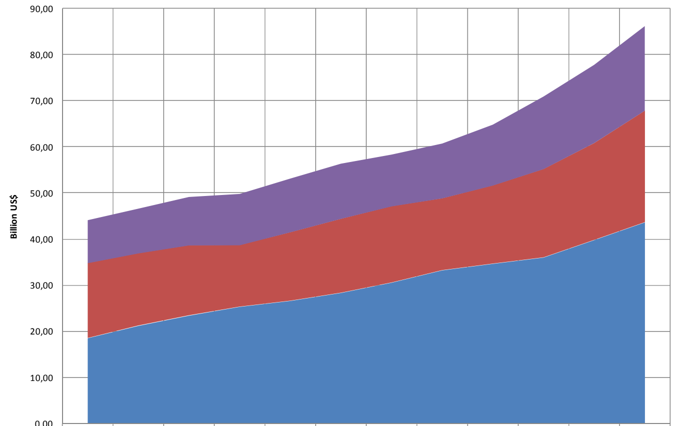
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
RWORLD	4,83	5,21	5,30	5,71	6,24	6,21	6,63	6,92	7,47	8,30	8,62	9,11
APEC	6,35	6,37	6,51	6,31	6,72	7,00	7,75	8,47	9,05	10,24	11,41	12,34
PR China	20,02	22,21	24,03	27,07	30,04	32,44	34,21	36,58	38,69	41,33	43,27	45,30

Source: FAO FISHSTAT

During the period 1995-2006, the PR of China presented an average annual growth rate for aquaculture production in volume, of approximately 9%, while the other APEC economies, without including PR of China, and the rest of the rest of the world had an average annual growth rate of approximately 10%. During the same period, the average annual growth rates for aquaculture production in value was of 13% and 6% for PR of China, APEC without China and the rest of the world respectively.

[1] Source on hard data on aquaculture production and others is FAO Fisheries and Aquaculture Information and Statistics Service, 2008: specifically from the Aquaculture production 1950-2006 dataset worked through the FISHSTAT Plus - Universal software for fishery statistical time series online, from the Food and agriculture Organization of the United Nations. Available at: http://www.fao.org/fi/statist/FISOFT/FISHPLUS.asp

Figure 2 Nominal value of world aquaculture production (billion US$), period 1995-2006



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
RWORLD	9,35	9,72	10,51	11,16	11,67	11,99	11,22	11,91	13,22	15,76	16,99	18,36
APEC	16,29	15,72	15,24	13,37	14,89	16,08	16,58	15,61	16,98	19,21	21,04	24,21
PR China	18,48	21,17	23,40	25,29	26,57	28,32	30,54	33,22	34,65	36,00	39,80	43,66

Source: FAO FISHSTAT

2.1.2 Within the APEC region

The composition of aquaculture production within the APEC community for 2006 showed Asia as the most important area with 83% and 77% of the APEC production in volume and value respectively (Table 1). The next most important areas were South and North America. In volume terms North America represented an 8% and South America a 6% approximately. In value terms the order of importance reverted with South America representing an 11% and North America a 9% of the total APEC aquaculture value in year 2006. The less important areas Oceania and Europe with importance ranging from 1.5% to 2% on volume and value for the first, and a 1% for volume and value of production for the later.

Table 1 Regional contribution to aquaculture production (volume and value) within the APEC community

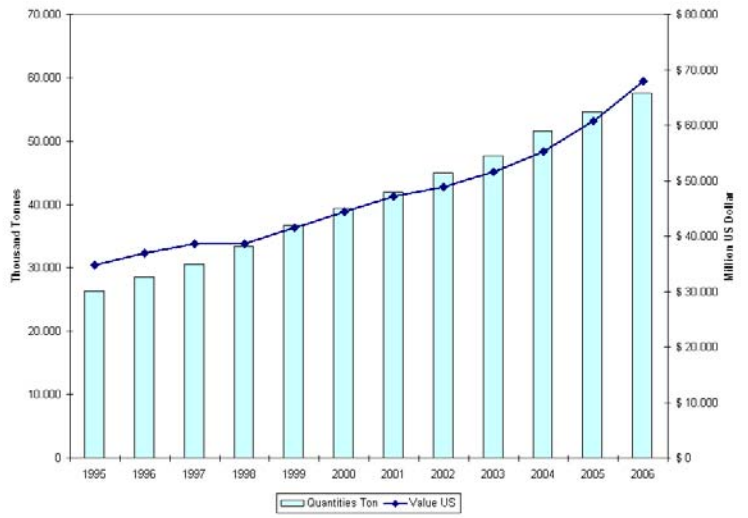
Region	Volume	Value
Asia	83.0%	77%
South America	6.3%	11%
North America	8.2%	9%
Oceania	1.5%	2%
Europe	1%	1%

Source: FAO FISHSTAT

FAO statistics show that aquaculture production in the APEC region has steadily increased during the period 1995-2006, this increase, however was heavily influenced by the faster growth of aquaculture in the PR of China. Figure 3 shows the evolution of aquaculture production (volume and value) and in 2006 it reached approximately 58 million tones and 70 billion US$.

Figure 4 shows the evolution of aquaculture in the APEC region differentiating the production of the PR of China of the rest of the economies forming the cooperation, and with and average annual growth rate of approximately 6%. According to FAO data, the rest of the APEC economies produced 12.3 million tons and 24.4 billion US$ during year 2006.

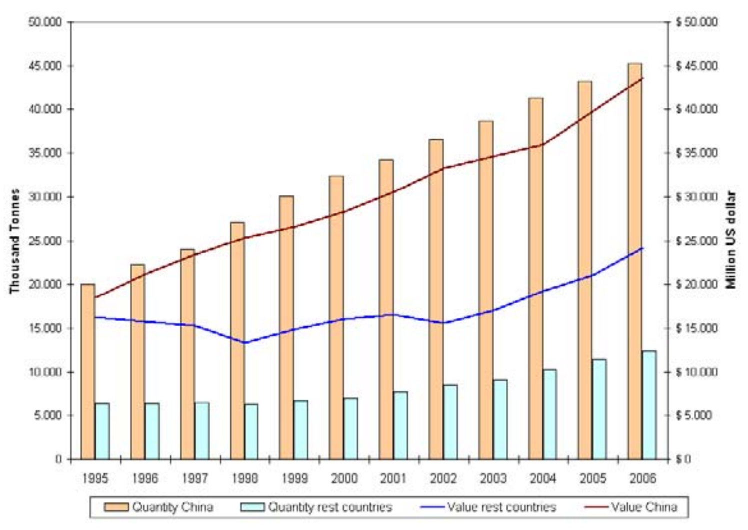
Figure 3 Evolution of aquaculture production in the APEC Region, (volume and nominal value period 1995-2006)



Source: FAO FISHSTAT

During the same period PR of China aquaculture production in volume had an average annual growth of 7%, producing a total of approximately 44 million tones and 44 US$ billion during year 2006.

Figure 4 APEC aquaculture production differentiating PR China, (volume and nominal value period 1995-2006)

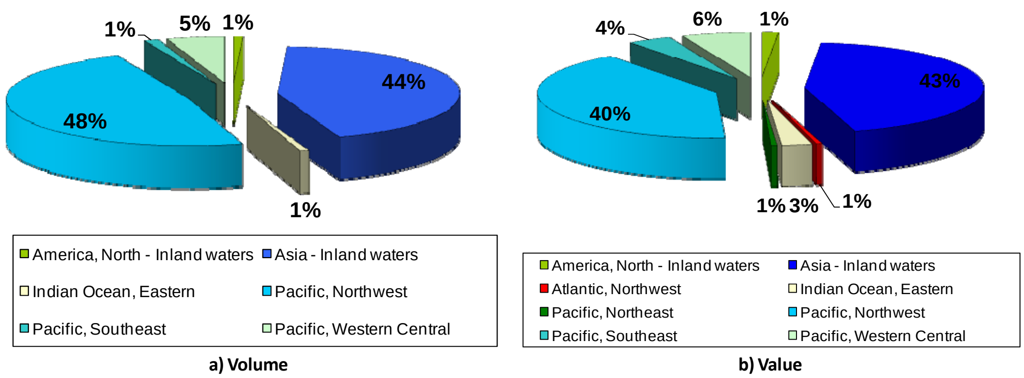


Source: FAO FISHSTAT

2.1.2.1 Current situation by geographic area, environment, group of species and economies

Figure 5 shows the relative importance of aquaculture product by geographical area within the APEC region during 2006. Clearly the Southeast Pacific and Inland waters of Asia are the most important areas. The Southeast pacific represented 48% and 40% of the total aquaculture volume and value, respectively. Inland waters of Asia represented a 40% and 43% of the total in volume and value respectively for 2006.

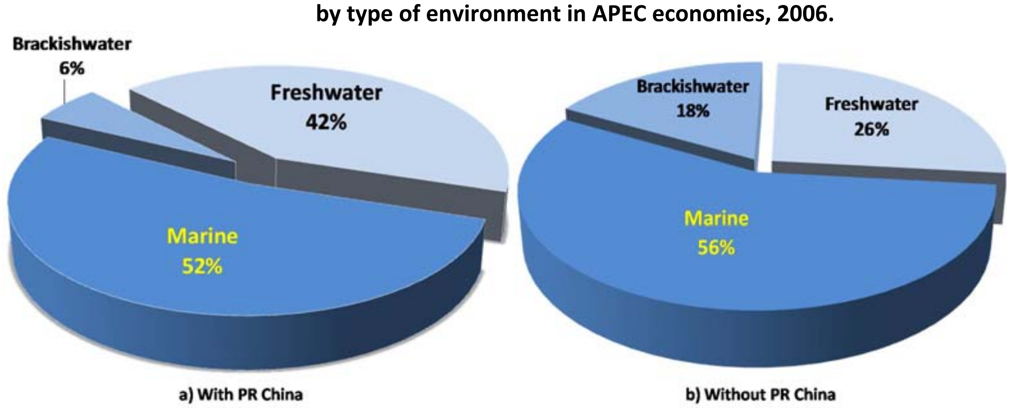
Figure 5 Relative importance aquaculture production (volume and value) by geographic area in the APEC region, 2006



Source: FAO FISHSTAT

APEC economies conduct aquaculture in three type of environments, namely marine, brackish water and freshwater. Figure 6 shows the distribution of aquaculture production in volume during 2006. This figure clearly shows that the marine environment was the most used ecosystem for aquaculture by APEC economies, generating from 52% to 56% of the total physical production in 2006, depending on whether the production from the PR of China is included or not.

Figure 6 Distribution of the aquaculture production (volume) by type of environment in APEC economies, 2006.



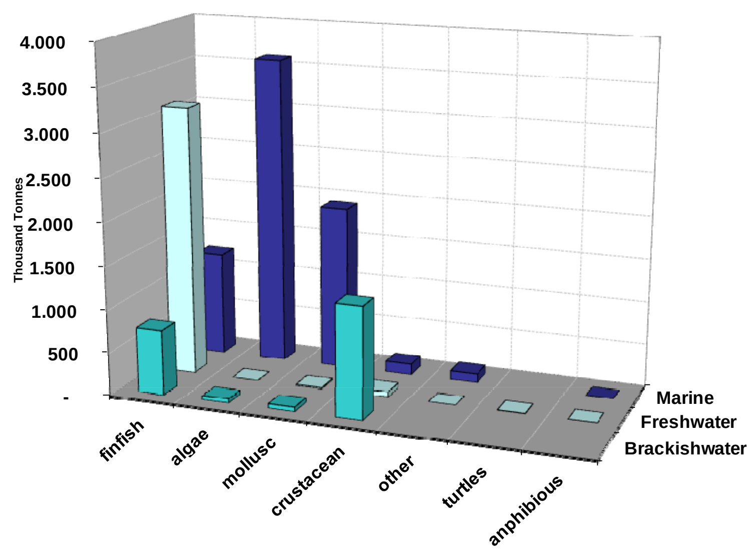
Source: FAO FISHSTAT

Figure 6b shows that fresh water environment provided in 2006 up to 42% of the total physical aquaculture production if the PR of Chine is included, but only 26% for the rest of the APEC economies. Brackish water environment was relatively more important for the rest of the APEC economies.

With respect to the environmental use for aquaculture in the APEC region for 2006, Figure 7 shows that fresh water was the most relevant ecosystem, largely due to finfish production. Crustaceans, mollusks, algae, amphibious, turtles and other group of species are also produce in fresh water environments. The marine environment was the second most important, mostly due to the production algae, mollusk, finfish and crustaceans. Brackish water environment is the remaining environment used in 2006, with crustaceans and finfish as the most important group of species produced in it.

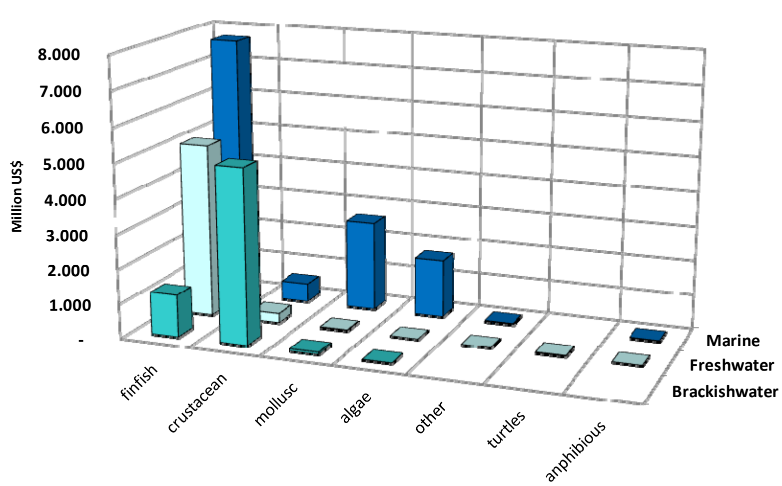
Figure 8 shows the relative importance of brackish water, freshwater and marine ecosystems in terms of their contribution to the total value of aquaculture production (million US$) in 2006. Clearly the relative importance of marine and brackish water aquaculture increases as production is based upon high market value species like shrimp, salmon and mollusks.

Figure 7 Volume of aquaculture production of APEC Economies in 2006 (w/o PR China, by species groups and environment)



Source: FAO FISHSTAT

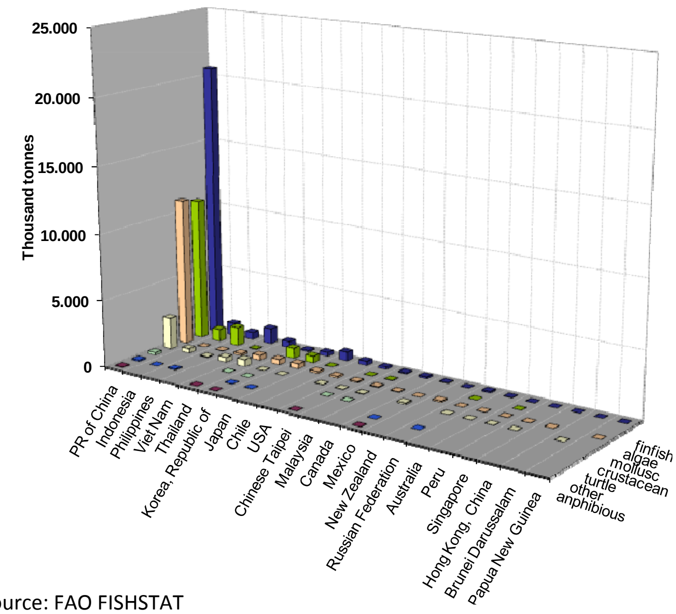
Figure 8 Nominal value of aquaculture production of APEC Economies in 2006 (w/o PR China, by species groups and environments)



Source: FAO FISHSTAT

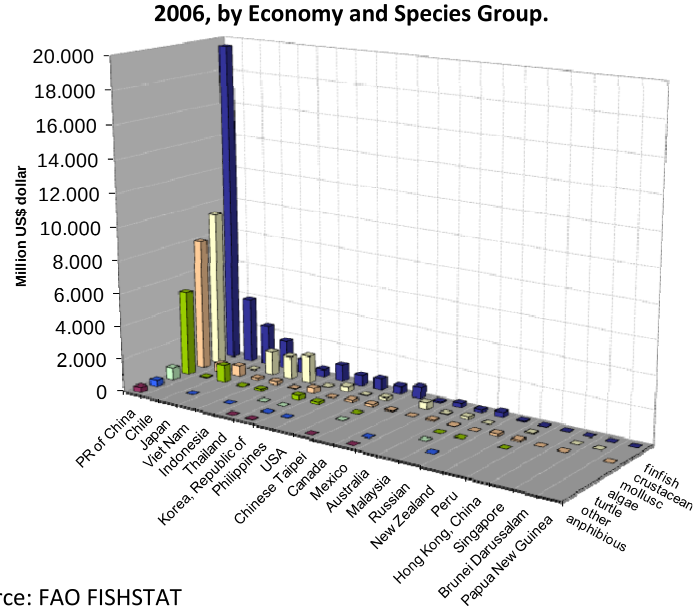
Figure 9 clearly shows that PR of China is a dominant player in aquaculture production in physical terms, followed far below by Indonesia, Philippines, Viet Nam, Thailand, R. of Korea and Japan. Most important groups of species are finfish, algae and mollusks. In value terms, PR of China continues to be the dominant player but, Chile and Japan now move to the second and third position respectively. Viet Nam keeps its fourth position in the ranking (Figure 9).

Figure 9 Volume of aquaculture production of APEC Economies in 2006 (including PR China, by Economy and Species Group)



Source: FAO FISHSTAT

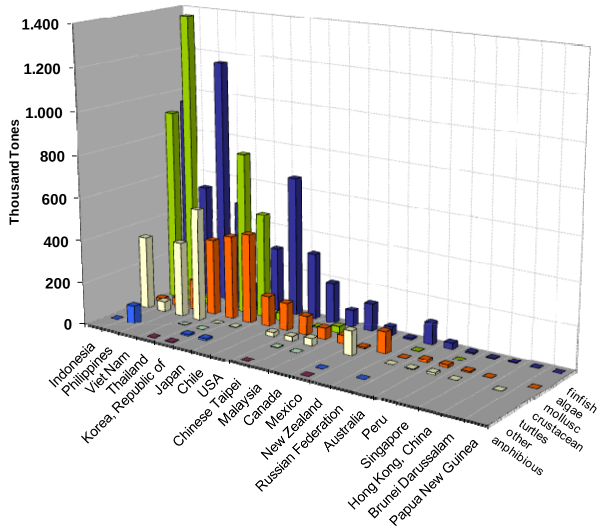
Figure 10 Relative importance of aquaculture production (value) in the APEC Region, 2006, by Economy and Species Group.



Source: FAO FISHSTAT

Figure 11 shows, when the PR of China is not included in the analysis, that a total of 7 economies had significant levels of physical production in 2006, with 7% or more of the total annual production in volume. These economies all together represent an 87% of the total production of the APEC region (without PR of China) and they are, in order of importance, Indonesia, The Philippines, Viet Nam, Thailand, the Republic of Korea, Japan and Chile.

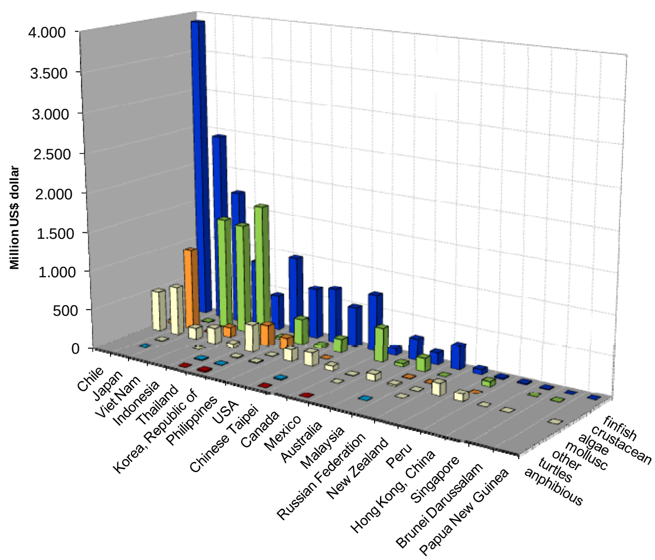
Figure 11 Volume of aquaculture production of APEC Economies in 2006 (w/o PR of China, by Economy and Species Group).



Source: FAO FISHSTAT.

Figure 12 in turn shows that in terms of aquaculture production value there are also 7 lead economies, which contribute with 5% or more to the total value of production that year and that, altogether they represented an 81% of the total value of aquaculture production from the region, discounting PR of China.

Figure 12 Nominal value of aquaculture production of APEC Economies in 2006 (w/o PR of China, by Economy and Species Group).



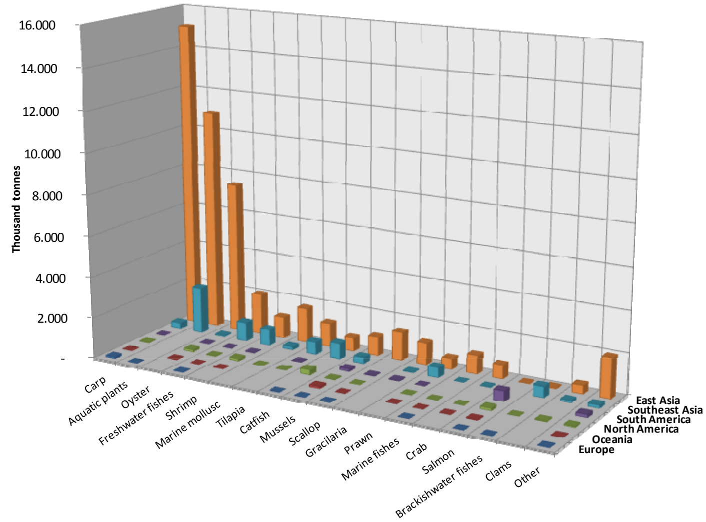
Source: FAO FISHSTAT

2.1.2.2 Main aquaculture species in the APEC region

Seventeen types of species were cultured in the APEC region in 2006 and they represented a 95% of the total production in volume. Most of them were produced in Asia (East and South East Asia), others in South and North America and other areas of the APEC region (Figure 13)

Carps, Aquatic plants and Oyster alone counted for about 63% of the total production in volume on 2006.

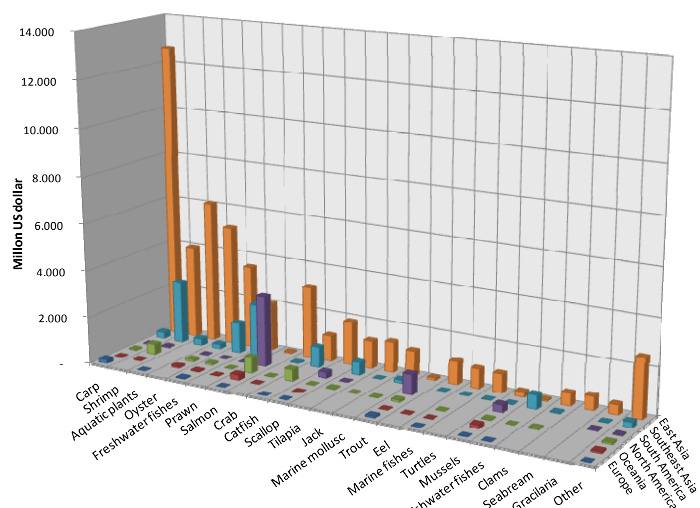
Figure 13 Volume of aquaculture production in the APEC region in 2006 (by type of species and geographic area)



Source: FAO FISHSTAT

Figure 14 shows the composition of the most important types of species in value produced through aquaculture in the APEC region. These are 22 types which in total represented approximately 96% of total aquaculture production value for year 2006. Carps, shrimp, oysters, freshwater fish, prawns and salmon, represented about 67% of the total value produced in 2006.

Figure 14 Nominal value of aquaculture production in the APEC region in 2006 (by type of species and geographic area)

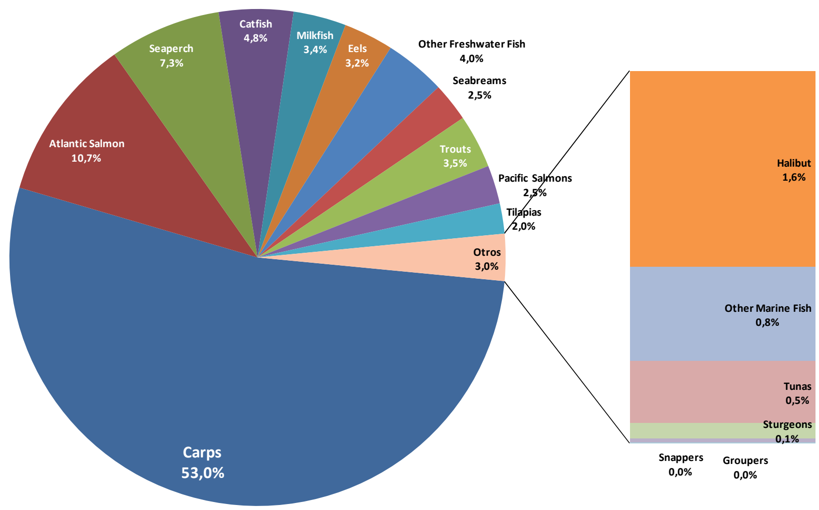


Source: FAO FISHSTAT

2.1.2.2.1 Finfish aquaculture

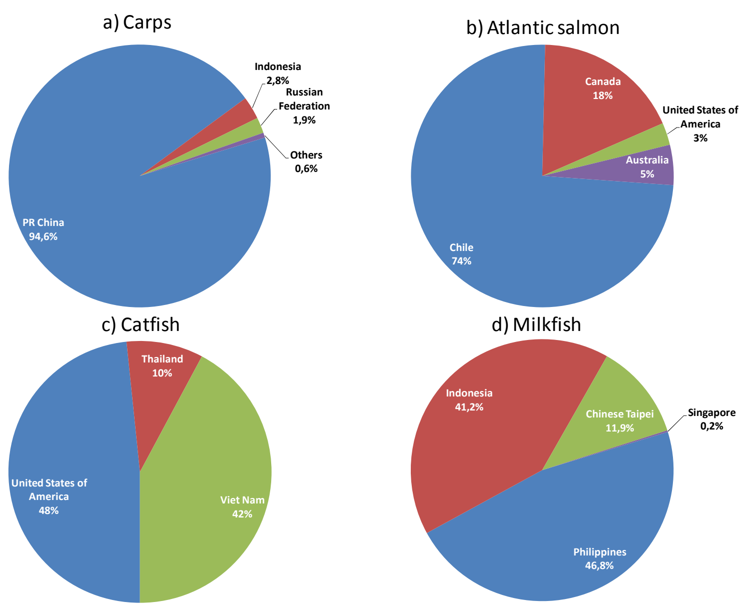
As shown by figure 15, most important finfish species in real value terms for APEC economies are: carps, Atlantic salmon, sea-perches, catfish, trout, milkfish and eels. During the period 2000-2006, various species of carps represented in average a 53% of the total annual aquaculture production value in real terms, with an annual value of 8.76 billion US$ (2005=100%), followed far bellow by Atlantic salmon with a 10.76% of the average annual value (1.76 billion US$ of 2005), sea-perches representing a 7.3% and catfish with a 4.8% of the annual value.

Figure 15 Most important finfish aquaculture species in APEC region in real value terms,
(based on the average of real annual value of aquaculture 2000-2006, base year 2005)



Source: elaborated from FAO FishStat database and IMF Price Index information

Figure 16 Most important producers of carps, Atlantic salmon, catfish and milkfish in APEC region in real value terms, 2000-2006



Source: elaborated from FAO FishStat database and IMF Price Index information

Figure 16 shows that PR China is the largest producer of carps, representing a 94.6% of the annual carp aquaculture value in real terms (base year 2005). Indonesia and the Russian Federation are minor producers. Chile and Canada are the most important producers of Atlantic salmon, with a 74% and 18% of the annual aquaculture value for this specie in real terms. Australia and the USA are other minor producers. The two largest catfish producers in the period 2000-2006 were the USA and Viet Nam, representing a 48% and 42% of the annual production value, followed by Thailand with only a 10% of the annual aquaculture value for these species. Similarly, The Philippines and Indonesia were the largest milkfish producers with approximately a 47% and 41% of the total annual aquaculture production, followed by Chinese Taipei with approximately 12% of the annual value.

Table 2 below shows, for the main finfish aquaculture species in the APEC economies, that aquaculture is a very important system of production usually representing in average more than 70% of the total annual production for these species during the period 1995-2006. Some exceptions are represented by Tunas in Australia (32%), Carps, Tunas and Tilapias in Mexico (42%, 55% and 8%) and Other Freshwater species or Other Marine species in economies like Viet Nam, Hong Kong China, Canada and Peru.

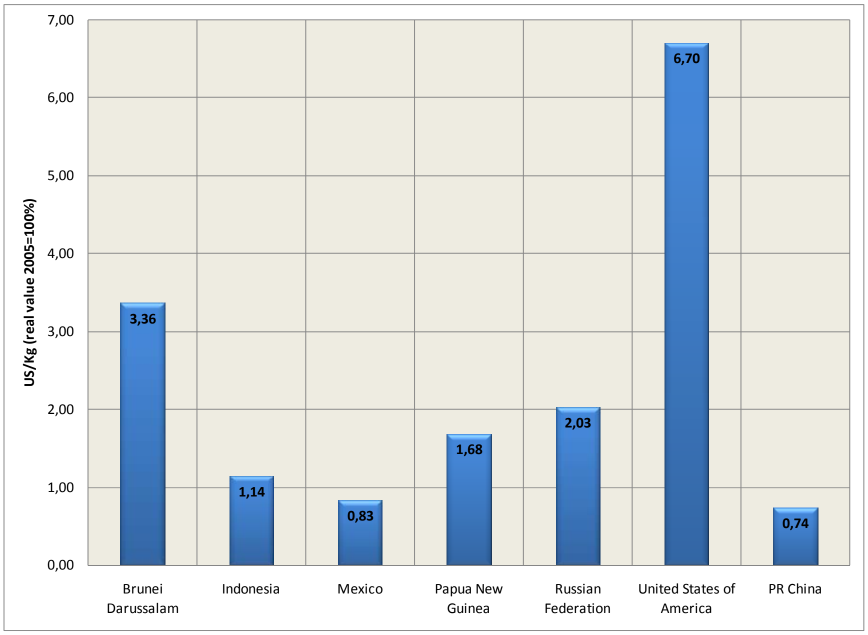
Table 2 Relative importance of aquaculture with respect to total fisheries production in the APEC Region, (based on average production of main finfish species, period 1995-2006).

		FINFISH																
REGION	ECONOMY	Atlantic Salmon	Carps	Catfish	Eels	Groupers	Halibuts	Milkfish	Pacific Salmons	Seabreams	Seaperch	Snappers	Sturgeons	Tilapias	Trouts	Tunas	Other Freshwater Fish	Other Marine Fish
Asia	Chinese Taipei				100%			100%						100%				
	Hong Kong, China					100%						100%						50%
	Japan				97%					84%	100%							
	Korea, Republic of				99%		91%											100%
	PR China		100%															
South East Asia	Brunei Darussalam		100%								100%			100%				
	Indonesia		96%					100%										
	Malaysia										72%			100%				
	Philippines							99%						70%				
	Singapore					58%		100%			82%							144%
	Thailand			100%										71%				
	Viet Nam			100%													67%	
Europe	Russian Federation		72%										80%		100%			
North America	Canada	100%							87%						100%		20%	
	Mexico		42%											8%	76%	55%		
	United States of America	100%	100%	100%											99%			
South America	Chile	100%							100%						100%			
	Peru													100%	84%		23%	
Oceania	Australia	100%														32%		
	New Zealand								100%									
	Papua New Guinea		100%												100%			

Source: elaborated from FAO FishStat datasets on total fisheries production and aquaculture production.
Note: please observe that available information presents some inconsistencies for Singapore data.

Figure 17 shows an annual unit value of production or apparent price (US$/kg), in real values base 2005 and weighted by annual productions during the period. As shown in Figure 17, the highest unit value of aquaculture carp production was reached in USA and Brunei Darussalam and the lowest by the PR if China, the world's largest producer of these species.

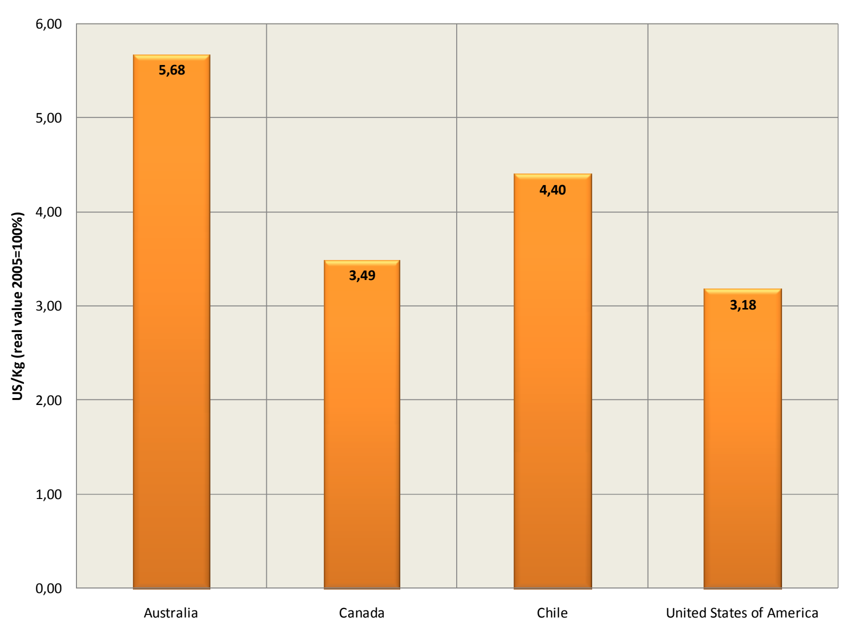
Figure 17 Weighted annual average unit value of aquaculture production of Carps in APEC region, (real values base 2005=100, period 2000-2006)



Source: elaborated from FAO FishStat database on aquaculture production and IMF Price Index.

Given the relative importance of these economies in the total aquaculture production it is possible to estimate a weighted annual average unit value for carps of 0.76 US$/kg, in real terms (base 2005).

Figure 18 Weighted annual average unit value of aquaculture production of Atlantic salmon in APEC region, (real values base 2005=100, period 2000-2006)

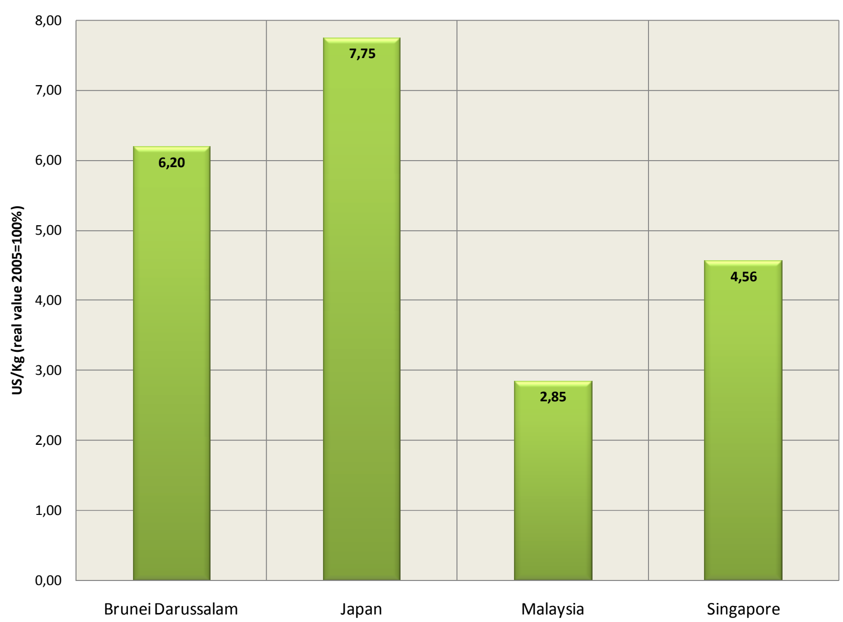


Source: elaborated from FAO FishStat database on aquaculture production and IMF Price Index.

Figure 18 shows weighted unit values for aquaculture production of Atlantic salmon in the APEC region with Australia and Chile reaching the highest average apparent price of production during the period 2000-2006. Canada and USA showed the lowest unit value. The weighted annual average unit value of aquaculture production of Atlantic salmon for these economies during the period 2000-2006 was of 4.21 US$/kg in real terms (base 2005).

Sea-perches, the third most important group of finfish species produced by aquaculture in the APEC region reached a higher weighted annual average unit value during the period 2000-2006, which was of 7.62 US$/kg in real terms (base 2005). Figure 19 shows the average unit value reached by the producing economies in the APEC region during the same period.

Figure 19 Weighted annual average unit value of aquaculture production of Sea-perches in APEC region, (real values base 2005=100, period 2000-2006)



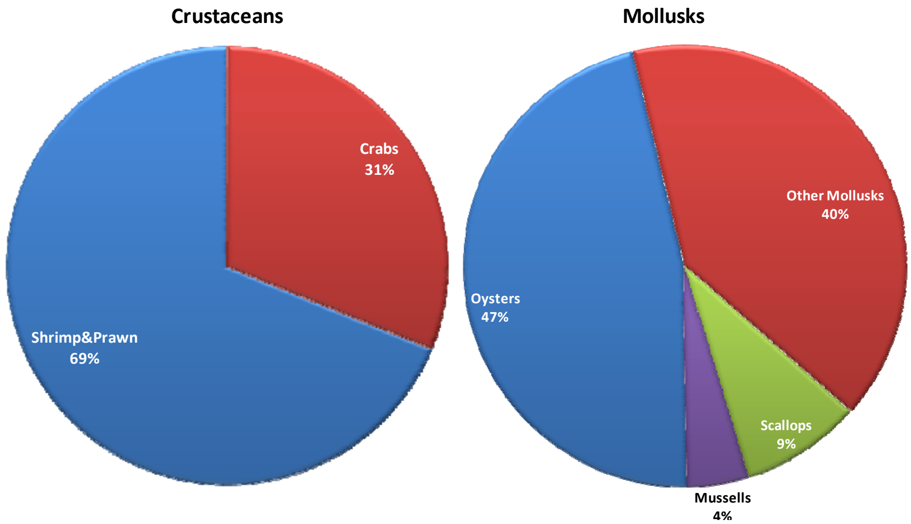
Source: elaborated from FAO FishStat database on aquaculture production and IMF Price Index.

Table A21, Appendix II, presents a breakdown of unit values for all the main aquaculture species in the APEC region.

2.1.2.2.2 Mollusks and crustaceans aquaculture

Figure 20, shows most important crustacean and mollusk species in real value terms for APEC economies are: shrimps & prawns, crabs, oysters, mussels and scallops. During the period 2000-2006, various species of shrimps & prawns represented in average a 69% of the total annual crustacean aquaculture production value in real terms, with an annual value of 3.84 billion US$ (2005=100%), followed by crabs with 31% of the average annual value (1.73 billion US$ of 2005).Simultaneously, Oysters represented an average 47% of the total mollusks aquaculture production value in real terms, with an annual value of 2.5 billion US$ (2005=100%), followed far below by scallops and mussels with a 9% (487 million US$) and 4% (259 million US$), respectively of the annual value.

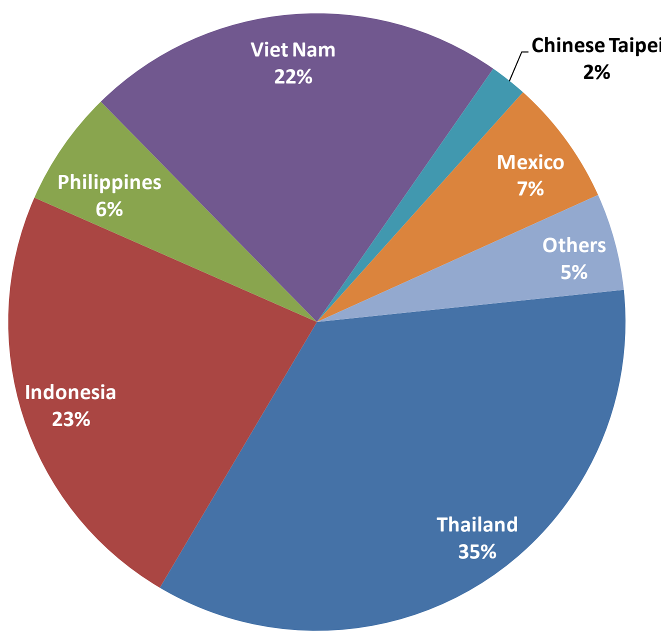
Figure 20 Most important aquaculture crustacean and mollusks species in APEC region in real value terms,
(based on the average of real annual value of aquaculture 2000-2006, base year 2005)



Source: elaborated from FAO FishStat database and IMF Price Index information

Figure 21 shows that Thailand, Indonesia and Viet Nam are the largest producers of shrimps & prawns during the period 2000-2006. These three economies represent a 35%, 23% and 22% of the total annual aquaculture value of Shrimp & Prawn, in real terms (base year 2005). Mexico, the Philippines and Chinese Taipei are minor producers with 7%, 6% and 2%.

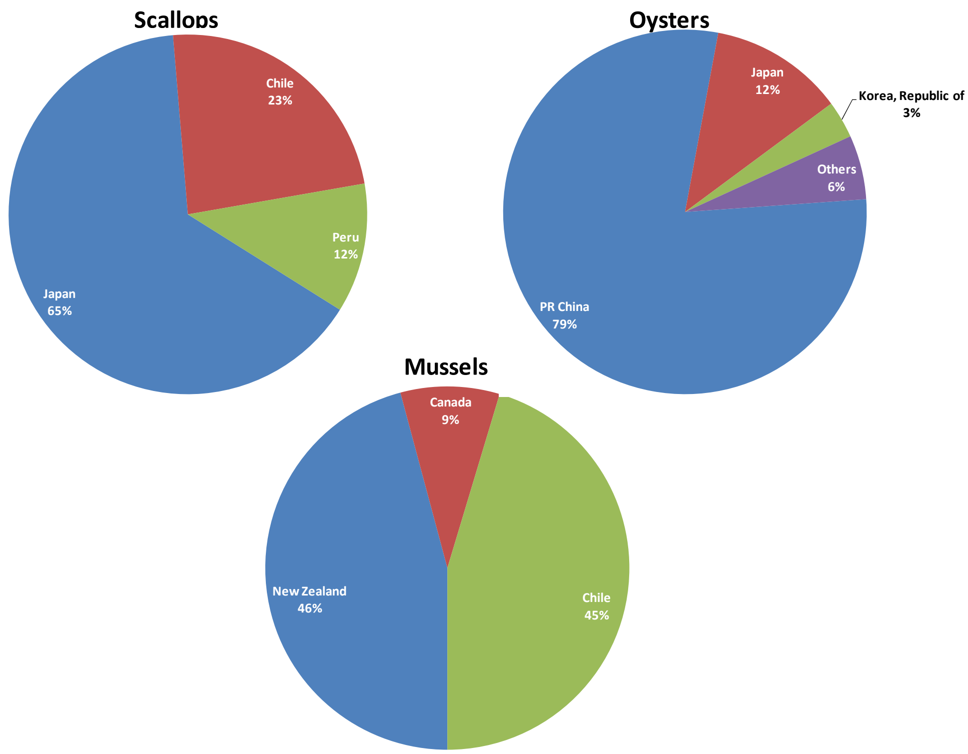
Figure 21 Most important producers of Shrimp and Prawns in APEC region in real value terms, 2000-2006



Source: elaborated from FAO FishStat database and IMF Price Index information

PR China is the largest producer of Oysters with a 79% of the annual aquaculture value for these species in real terms. Japan and the Republic of Korea are smaller producers with 12% and 2% of the total annual value respectively. With respect to aquaculture production of scallops during the same period, Japan is the largest producer in the APEC region with 65% of the total annual value of the production, followed far below by Chile (22%) and Peru (12%), respectively. New Zealand and Chile were the largest players in mussel production in the APEC region during the period 2000-2006, with 46% and 45% of the annual value of aquaculture production of these species in real terms, far followed by Canada with 9% of the total annual production value.

Figure 22 Most important producers of mollusks in APEC region in real value terms, 2000-2006



Source: elaborated from FAO FishStat database and IMF Price Index information

Table 3 shows, for the main crustacean and mollusks species cultured in the APEC economies, that aquaculture is also a very important system of production usually representing, in average, more than 70% of the total annual production for these species during the period 1995-2006. Some exceptions are represented by Scallops in Japan and Peru, Oysters in the USA and, shrimp & prawn in Australia.

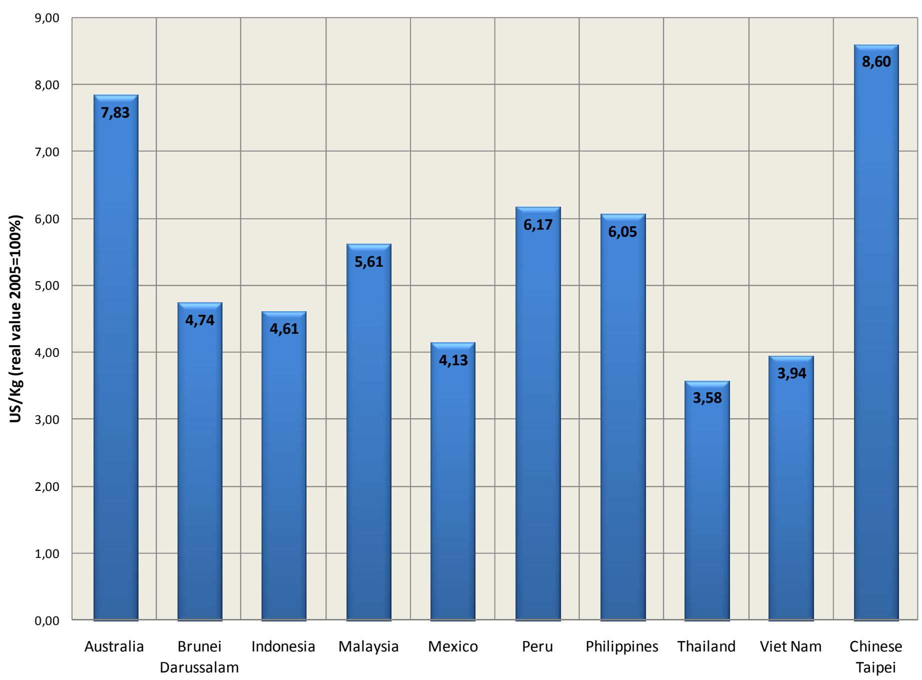
Unit value of Shrimp & Prawn aquaculture production, expressed in real terms year (2005=100%) in Figure 23, show that in average Chinese Taipei and Australian producers have fetched higher values (7.8 and 8.6 US$/kg, respectively) for their productions during the period 2000-2006.

Table 3 Relative importance of aquaculture with respect to total fisheries production in the APEC Region, (based on average production of main crustacean and mollusks species, period 1995-2006).

REGION	ECONOMY	CRUSTACEANS		MOLLUSKS					OTHER
		Crabs	Shrimp&Prawn	Abalones	Mollusks	Mussells	Oysters	Scallops	Other sps
Asia	Chinese Taipei		100%				100%		10%
	Hong Kong, China								5%
	Japan						100%	44%	13%
	Korea, Republic of				100%		92%		32%
	PR China	97%			100%		100%		66%
South East Asia	Brunei Darussalam		100%						2%
	Indonesia		60%						14%
	Malaysia		100%		100%				4%
	Philippines	71%	99%						46%
	Singapore	370%							44%
	Thailand		99%						11%
	Viet Nam		100%						6%
Europe	Russian Federation								0%
North America	Canada					96%			2%
	Mexico		100%						0%
	States of America						37%		2%
South America	Chile					81%		100%	1%
	Peru		100%					30%	0%
Oceania	Australia		28%				100%		4%
	New Zealand			0%		100%	100%		
	Papua New Guinea								0%

Source: elaborated from FAO FishStat datasets on total fisheries production and aquaculture production.
Note: please observe that available information presents some inconsistencies for Singapore data.

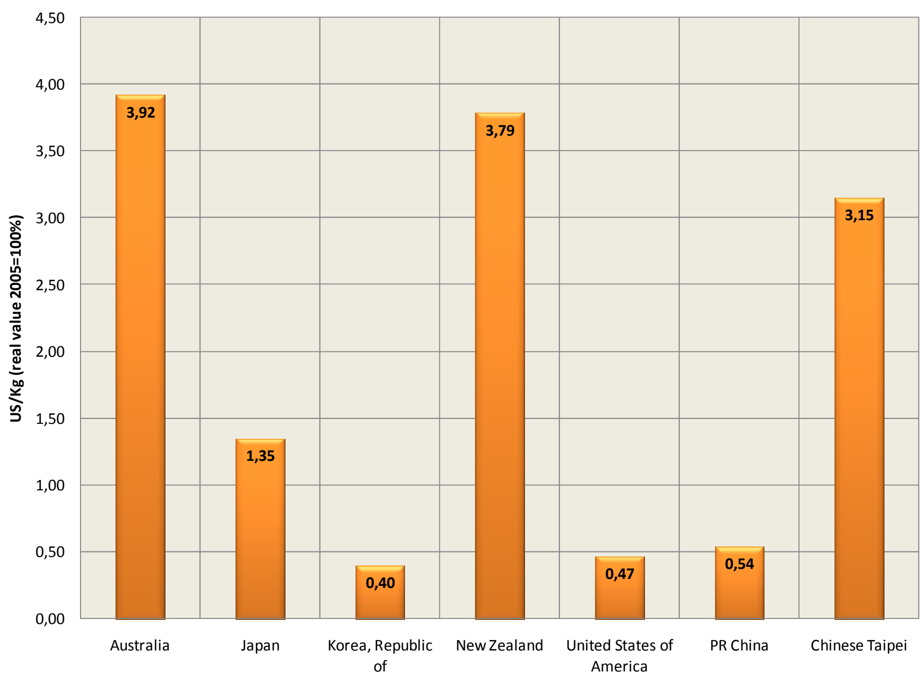
Figure 23 Weighted annual average unit value of aquaculture production of Shrimp & Prawns in APEC region, (real values base 2005=100, period 2000-2006)



Source: elaborated from FAO FishStat database on aquaculture production and IMF Price Index.

Figure 23 shows that other economies like Peru, the Philippines, Malaysia, Brunei Darussalam, Indonesia and Mexico have been producing Shrimp & Prawns with an average unit value ranging from 4.1 to 6.2 US$/kg in real terms (year 2005=100%), during the same period. Figure 23 also shows that in average Thailand and Viet Nam produced Shrimp & Prawns under a unit value of 4 US$/kg in real terms.

Figure 24 Weighted annual average unit value of aquaculture production of Oysters in APEC region, (real values base 2005=100, period 2000-2006)



Source: elaborated from FAO FishStat database on aquaculture production and IMF Price Index.

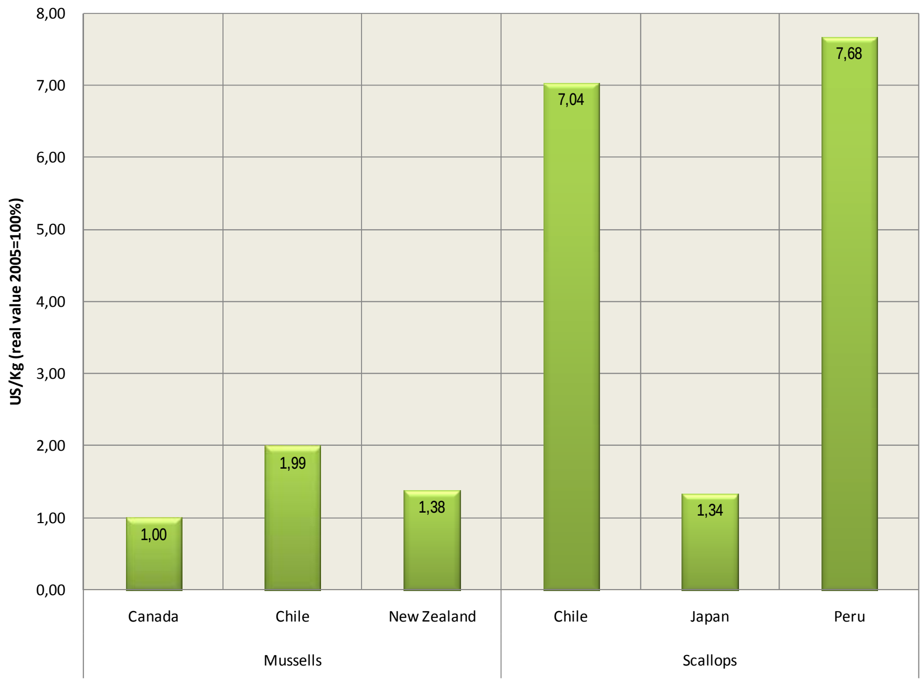
Figure 24 shows that Australia, New Zealand and Chinese Taipei have produced aquaculture Oysters with an average unit value ranging from 3.9 to 3.2 US$/kg in real terms (2005=100%) during the period 2000-2006. The same figure 24 shows that Japan have produced oysters with unit value of approximately 1.4 US$/kg in real terms and that Oyster aquaculture production from the Republic of Korea, USA and PR China have not surpassed 0.6 US$/kg in real terms, during this period.

The unit value reached by the aquaculture production of Mussels and Scallops, in real terms (year 2005=100%) during the period 2000-2006 is show in Figure 25. Figure 25 shows that Scallops produced by Peru and Chile, reached significantly higher unit value with more than 7 US$/kg than for Scallops produced in Japan which reached only 1.3 US$/kg.

Figure 25 also shows that during the same period 2000-2006, aquaculture Mussels production from Canada, Chile and New Zealand ranged from more than 1 US$/kg to less than 2 US$/kg in average and expressed in real terms (year 2005=100%).

Table A21, Appendix II, presents a breakdown of unit values for all the main aquaculture species in the APEC region.

Figure 25 Weighted annual average unit value of aquaculture production of Mussels and Scallops in APEC region, (real values base 2005=100, period 2000-2006)



Source: elaborated from FAO FishStat database on aquaculture production and IMF Price Index.

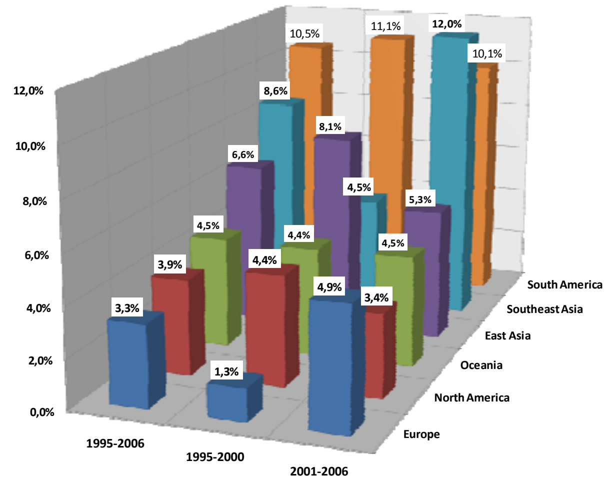
2.1.2.3 Aquaculture trends in the APEC region

2.1.2.3.1 Trends in production volume

Aquaculture production has shown positive growths rates during the period 1995-200 and the most dynamic region were South America, East Asia and South East Asia. When considering an average annual growth rate for the entire period 1995-2000, South America showed an annual growth of approximately 11%, in volume of production, followed by East Asia and South East Asia with about an annual 9% and 7% growth in physical production, respectively. APEC economies from Oceania and North America showed only an annual 4% growth in physical production, followed by Europe (Russian Federation) with a 3% annual growth (Figure 26).

When considering two sub periods, first 1995-2000 and second 2001-2006 some variations in growth may be perceived. Economies from South East Asia experienced a significant increase in their annual growth rate, upgrading from an annual 4.5% during the first period (1995-2000) to an annual 12% growth rate during 2001-2006. On the contrary, economies from East Asia experienced a decrease in its growth pace, falling from an annual 8% during 1995-200 to a 5.3% during 2001-2006. Simultaneously North America showed a small decrease in its annual growth falling from an annual 4.4% during 1995-200 to a 3.4% during 2001-2006. South America also experienced a small decrease in its annual growth rate. Europe started with a low growth pace of 1.3% annual growth in the volume of production, increasing to almost a 5% annual growth for the period 2001-2006. Oceania maintained its growth pace.

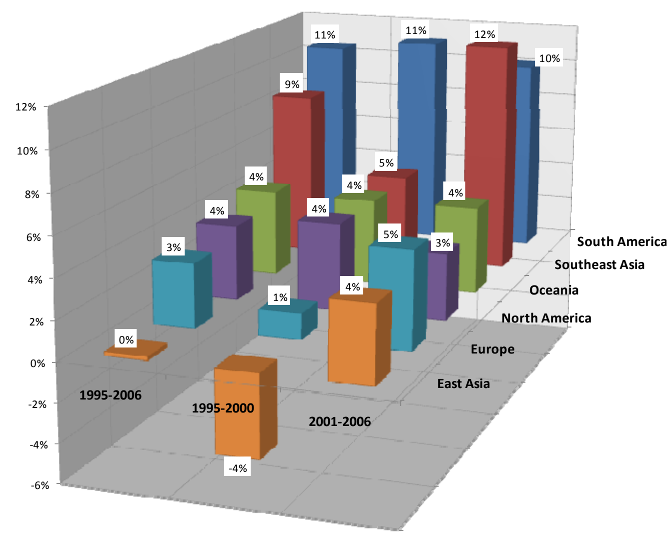
Figure 26 Growth rate of aquaculture production (volume) in the APEC Region, between 1995-2006, by geographic area, including PR of China



Source: FAO FISHSTAT

As shown in Figure 26, the period 2001-2006 witnessed an important upgrade in the annual growth rate of physical aquaculture production in APEC economies from Southeast Asia and Europe with a higher growth rate. All other APEC economies and regions showed a fall in their annual rate of growth, with the exception of Oceania. A similar analysis but, without including the PR of China, showed that other APEC East Asian economies were not growing between 1995 and 2006 (Figure 27). A separate analysis actually shows that these economies experienced a fallback of approximately 4% annual reduction in physical production between 1995 and 2000. During the second period (2001-2006), nonetheless, they recovered their production levels at approximately the same pace they reduced it the previous period.

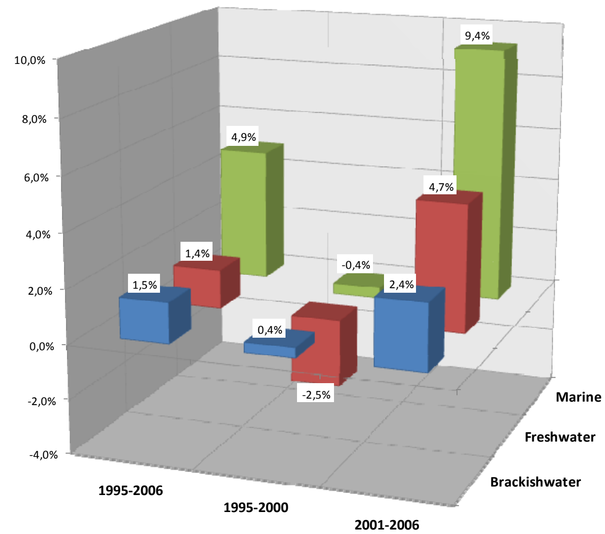
Figure 27 Growth rate of aquaculture production (volume) in the APEC Region, between 1995-2006, by geographic area, without PR of China



Source: FAO FISHSTAT

Figure 28 shows the annual rate of change of aquaculture in physical production in the APEC region by environment or type of ecosystem, without including the PR of China. During the period 1995-2006 there was an overall increase in the volume of production, which showed approximately a 5% annual growth in marine ecosystems and about 1.5% in freshwater and brackish water environments. When considering two sub periods, 1995-2000 and 2001-2006, it is observed that decreases were experienced by production in marine and freshwater environments between years 1995 and 2000 and that these where more than compensated during the next period. Mariculture is a special example as it experienced an annual growth rate of approximately 9% during the period 2001-2006.

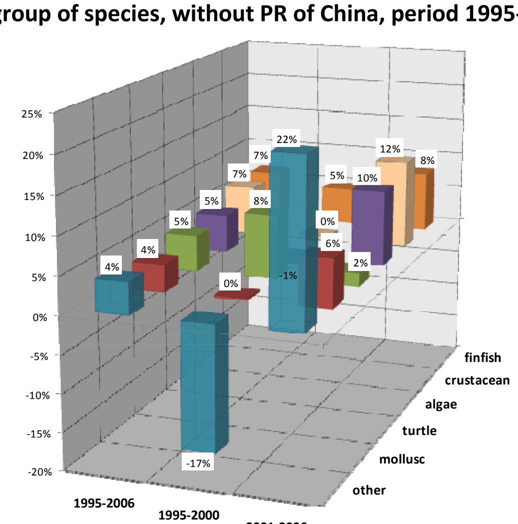
Figure 28 Growth rate of aquaculture production (volume) in the APEC Region, between 1995-2006, by ecosystems, without PR of China



Source: FAO FISHSTAT

Figure 29 shows variations in production by species groups during the same periods of time, also excluding production from the PR of China. As shown in this figure, aquaculture production in volume for all group of species experienced an overall increase during the period 1995-200. Finfish and crustaceans aquaculture production for example experienced an average annual growth rate of 7%. Other species groups increased at an annual rate of 4% to 5%. Distinction between periods 1995-2000 and 2001-2006, shows again some reductions and recoveries.

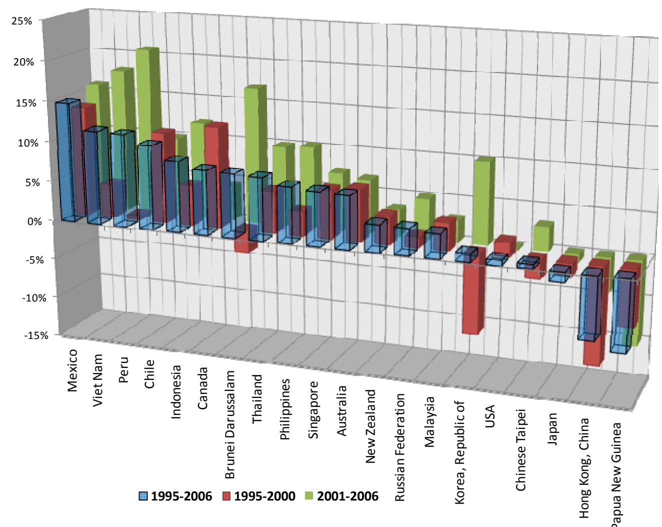
Figure 29 Average annual growth rate of aquaculture production (volume), in the APEC Region, by group of species, without PR of China, period 1995-2006



Source: FAO FISHSTAT

Finally, Figure 30 shows variations in aquaculture production by all economies in APEC with the exception of the PR of China, during the same period 1995-2006. Figure 30 clearly shows that 18 of these economies experienced an overall growth in their aquaculture production. Out of these 18 economies USA and Chinese Taipei experienced zero annual growth rates during the period. Others like Japan, Hong Kong China ad Papua New Guinea experienced reductions in the aquaculture production. Many economies in spite of first period 1995-2000 whit lower annual growth rates or even negative, recovered an even over passed growth during the next period 2001-2006. That is the case of Viet Nam, Peru, Indonesia and Brunei Darussalam and the Russian Federation. Others like Canada, Australia and New Zealand reduced their growth rate or maintained a lower one.

Figure 30 Average annual growth rate of aquaculture production (volume) in the APEC Region, by economy, without PR of China, period 1995-2006,



Source: FAO FISHSTAT

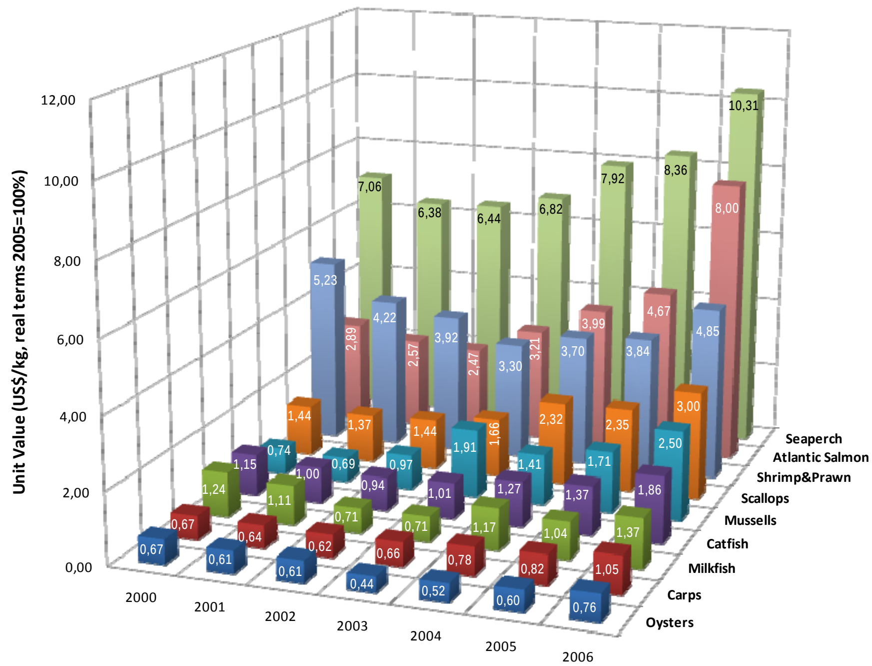
2.1.2.3.2 Trends in aquaculture production value

For this analysis, FAO FishStat data on aquaculture produced species was sorted according to “Customs group” this, as it is consistent across total fishery production, aquaculture production and commodities production and trade datasets. Regretfully, the use of “Customs Groups” implied that algae, seaweeds or aquatic plant information has not been considered on this analysis.

Figure 31 shows that aquaculture species reaching the highest values are, in order of importance, Sea-perches, Shrimp & Prawns, Atlantic salmon and scallops. It is also shown that the average annual unit value of Sea-perches and Atlantic salmon steadily increased in real terms between 2001 and 2006. Atlantic salmon showed the largest average annual growth rate for the period with a 21% growth in annual unit value (US$/kg). During the same period scallops showed an average annual growth rate of 14% and Sea-perches of 7%.

Among lower unit value species, it is possible to highlight that Mussels showed a 29% increase in the weighted average unit value of aquaculture production and that Carps have shown a steady increase of 8% annually in their unit value in real terms during the period 2000-2006 (Figure 31).

Figure 31 Annual average unit value (US$/Kg) for the main aquaculture species in the APEC region (in real terms 2005=100%), period 2000-2006.



Source: elaborated from FAO FishStat database on aquaculture production and IMF Price Index.

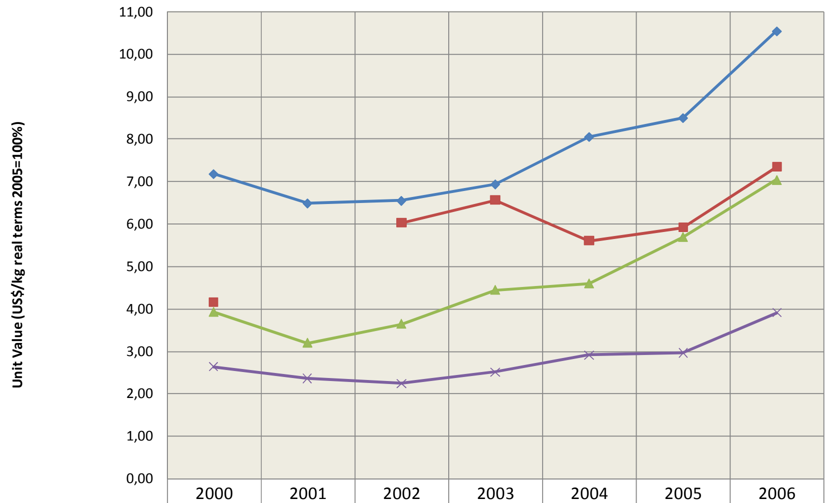
According to FAO FishStat data unit values of aquaculture production varies with species and also from one economy to other. Even though no specific information on how total value of aquaculture production by economy and species is calculated by FAO FishStat, it is assumed that variation in unit value depends on the specific set of species cultured in each economy and the markets were they sell their aquaculture products[2]. Thus, in addition to analyze the trends of the weighted annual average unit value for each of the relevant aquaculture produced species, it is also important to analyze the trends of their unit value for the most important economies producing these species in the APEC region.

Figure 32 shows a unit value for Sea-perches which is increasing in real terms during the period 2000-2006. Levels reached and annual growth rates in unit value vary with economies, nonetheless. Thus, even though Japan shows the highest unit values, in real terms, it grew at only 8% annually from year 2000 to 2006. Simultaneously, unit value of aquaculture produced Sea-perches in Singapore showed a significative 13% annual growth, but reached a highest value of 7.34 US$/kg in 2006, lower than the 10.54 US$/kg reached by Japanese production the same year.

During the same period, unit value in real terms for Malaysian Sea-perch aquaculture production ranged only from 2.64 US$/kg to 3.91 US$/kg, showing also an 8% annual growth rate.

[2] Nominal unit value (US$/kg) is calculated by dividing for the total nominal value of production by the total physical volume production, every period or year and for each separate specie reported.

Figure 32 Annual average unit value (US$/Kg) for Sea-perches in the APEC region, period 2000-2006 (in real terms 2005=100%).

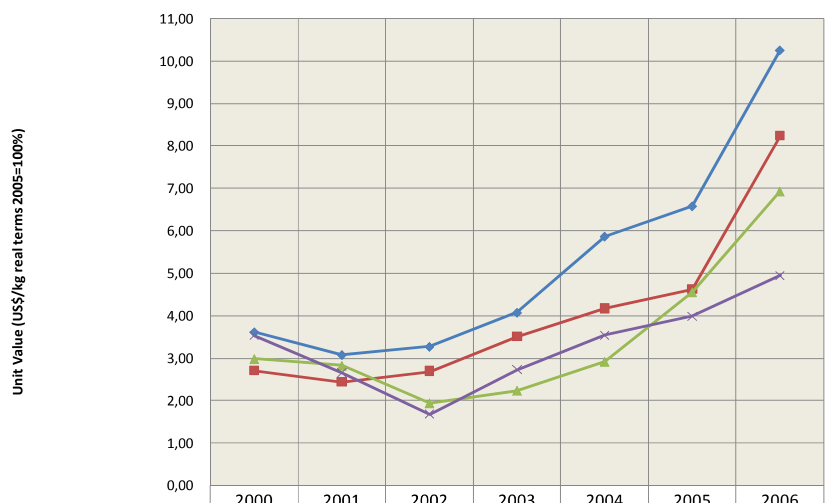


	2000	2001	2002	2003	2004	2005	2006
Japan	7,18	6,49	6,55	6,94	8,06	8,50	10,54
Brunei Darussalam	4,16		6,03	6,56	5,61	5,92	7,34
Singapore	3,93	3,20	3,65	4,45	4,60	5,70	7,04
Malaysia	2,64	2,37	2,25	2,51	2,92	2,97	3,91

Source: elaborated from FAO FishStat database on aquaculture production and IMF Price Index.

The unit value of Atlantic salmon aquaculture production also showed an increasing pattern during the period 2000-2006 (Figure 33).

Figure 33 Annual average unit value (US$/Kg) for Atlantic salmon in the APEC region, period 2000-2006 (in real terms 2005=100%).



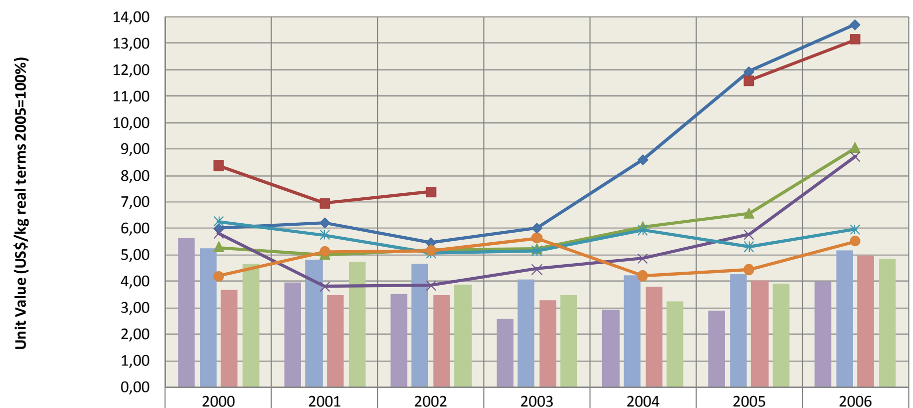
	2000	2001	2002	2003	2004	2005	2006
Australia	3,62	3,08	3,27	4,08	5,87	6,58	10,26
Chile	2,71	2,44	2,70	3,51	4,17	4,63	8,23
Canada	2,98	2,83	1,94	2,24	2,92	4,56	6,93
United States of America	3,53	2,65	1,68	2,73	3,54	3,99	4,95

Source: elaborated from FAO FishStat database on aquaculture production and IMF Price Index.

Australian and Chilean production reached the higher unit values with 10.26 and 8.23 US$/kg, respectively. These two economies also showed impressive increases in value with annual growth rates for the real unit value of 34% and 33%, for Chile and Australia, respectively. Canada also shows a large annual growth rate of 22% for the period but the USA experienced only a 7% annual growth rate.

Figure 34 shows the trend in unit value for the aquaculture produced Shrimp & Prawns in the APEC region during the period 2000-2006. Figure 34 clearly shows two distinct groups of producers, those that reached higher unit values, above 5.5 US$/kg (i.e., Chinese Taipei, Australia, the Philippines, Peru, Malaysia and Brunei Darussalam) and those under these barrier (i.e., Thailand, Indonesia, Viet Nam and Mexico).

Figure 34 Annual average unit value (US$/Kg) for Shrimp & Prawns in the APEC region, period 2000-2006 (in real terms 2005=100%).



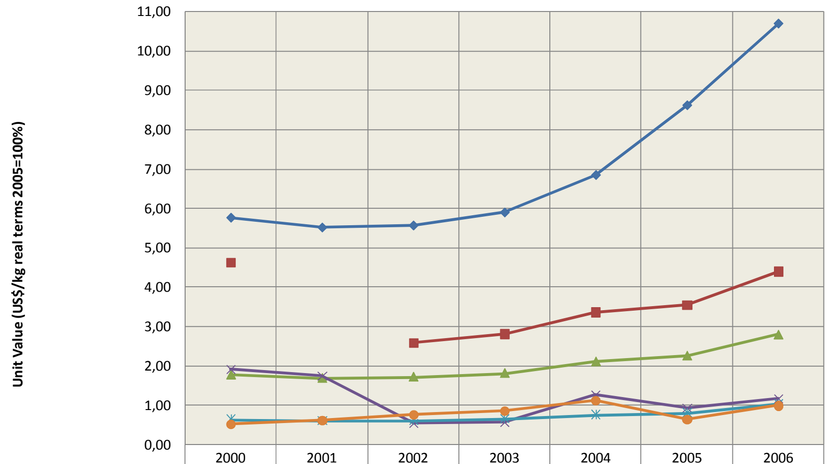
	2000	2001	2002	2003	2004	2005	2006
Thailand	5,61	3,93	3,51	2,55	2,91	2,87	3,97
Indonesia	5,24	4,80	4,65	4,04	4,20	4,23	5,17
Viet Nam	3,67	3,45	3,46	3,27	3,79	4,00	4,96
Mexico	4,63	4,71	3,84	3,45	3,22	3,89	4,85
Chinese Taipei	6,00	6,22	5,46	6,02	8,60	11,93	13,71
Australia	8,38	6,96	7,38			11,58	13,13
Philippines	5,29	5,00	5,19	5,22	6,05	6,56	9,05
Peru	5,83	3,81	3,84	4,46	4,86	5,77	8,71
Malaysia	6,25	5,75	5,06	5,15	5,93	5,31	5,96
Brunei Darussalam	4,20	5,11	5,17	5,62	4,21	4,44	5,51

Source: elaborated from FAO FishStat database on aquaculture production and IMF Price Index.

There are three observable trends in unit value of Shrimp & Prawns aquaculture production between year 2000 and 2006. First, a significative increase in its real value experienced production from economies like Chinese Taipei, Australia, the Philippines and Peru with an average annual growth rate ranging from 6% (Viet Nam) to 21% (Chinese Taipei). Second, a lower but still positive change in the real unit value experienced by Brunei Darussalam with an average annual growth rate of 5% and Mexico, with a marginal 0.8%. The third trend is a negative one represented by decreases in the real unit value in economies like Thailand, Malaysia and Indonesia, whose average annual growth rate ranged were -5%, -0.8% and -0.2%, respectively.

In turn, Figure 35 shows the trend in unit value for the aquaculture produced carps in the APEC region during the period 2000-2006. Three distinct groups in terms of level that the unit value reaches during this period, first those that are over the 5 US$/kg, second, those that do not reached the previous level barrier but have surpassed the 2 US$/kg and third, those that have never surpassed the 2 US$/kg barrier. The first group includes only the USA, the second group is comprised by Brunei Darussalam and the Russian Federation and the third group by Indonesia, PR China and Mexico.

Figure 35 Annual average unit value (US$/Kg) for Carps in the APEC region, period 2000-2006 (in real terms 2005=100%).



	2000	2001	2002	2003	2004	2005	2006
United States of America	5,77	5,52	5,57	5,90	6,85	8,62	10,69
Brunei Darussalam	4,63		2,58	2,81	3,37	3,55	4,40
Russian Federation	1,77	1,69	1,72	1,81	2,11	2,26	2,80
Indonesia	1,92	1,76	0,54	0,57	1,27	0,93	1,17
PR China	0,64	0,61	0,61	0,65	0,76	0,81	1,03
Mexico	0,52	0,61	0,76	0,86	1,12	0,63	0,99

Source: elaborated from FAO FishStat database on aquaculture production and IMF Price Index.

In terms of change in the unit value of the aquaculture carp production in real terms, data shown in Figure 35 also indicates three distinct groups. First, those with a significative increase in their unit value in real terms comprised by Mexico and the USA with an average annual growth rate of 15% and 14%, respectively. The second group includes PR China and the Russian Federation with an average annual growth of approximately 10% each. The third group includes those economies which experienced decreases in their unit value in real terms, including both Indonesia (-7%) and Brunei Darussalam (-0.8%).

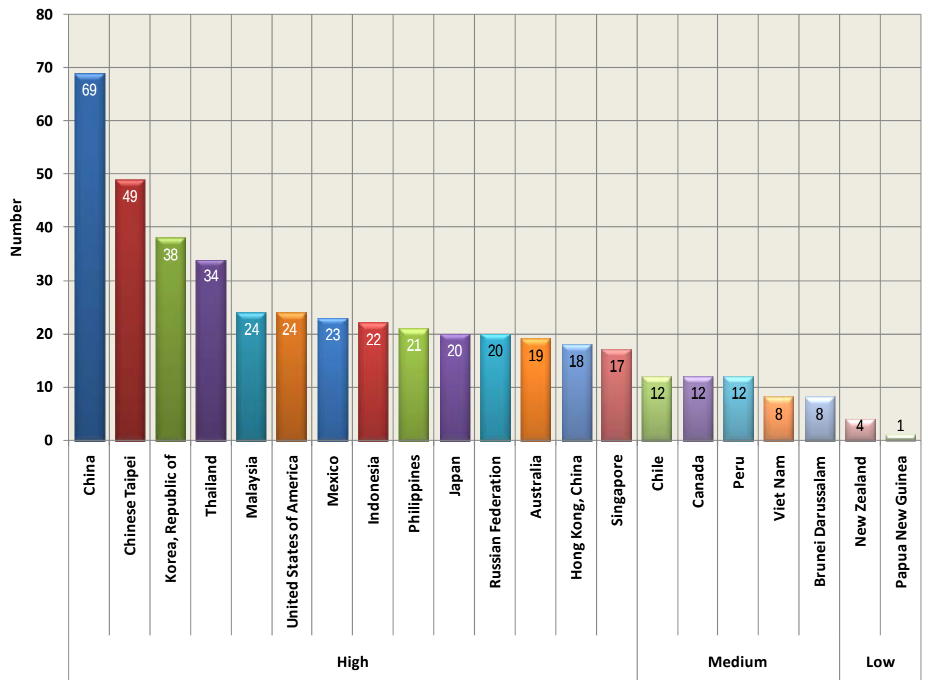
Table A21, Appendix II, presents a breakdown of unit values for all the main aquaculture species in the APEC region.

2.1.2.4 Vulnerability of aquaculture activity

In general, low levels of diversity of production in economic sectors or activities are regarded as a weakness. This is certainly true in economic activities highly dependents on natural resources and the environment, like aquaculture, were low levels of diversity either in terms if species and production systems may be regarded as a weakness factor in view of the highly dynamic context in which they operate (i.e., environment and markets). Environmental condition may vary not only because o natural problems but, most importantly due to anthropogenic impacts (i.e., animal diseases and ecosystems degradation, among other). Market conditions change not only due to changes in consumer tastes but also due to conditions of the overall economic system.

Figure 36 shows a histogram of the number of aquaculture produced specie for all APEC economies, as it may be observed that 14 economies of APEC have a highly diverse aquaculture sector with a total number of aquaculture produced species ranging from 20 to 69. It is also clear that PR China and Chinese Taipei have the most number of species cultured.

Figure 36 Number of aquaculture produced species in the APEC region, (mode for period 2000-2006)



Source: elaborated from FAO FishStat database on aquaculture production

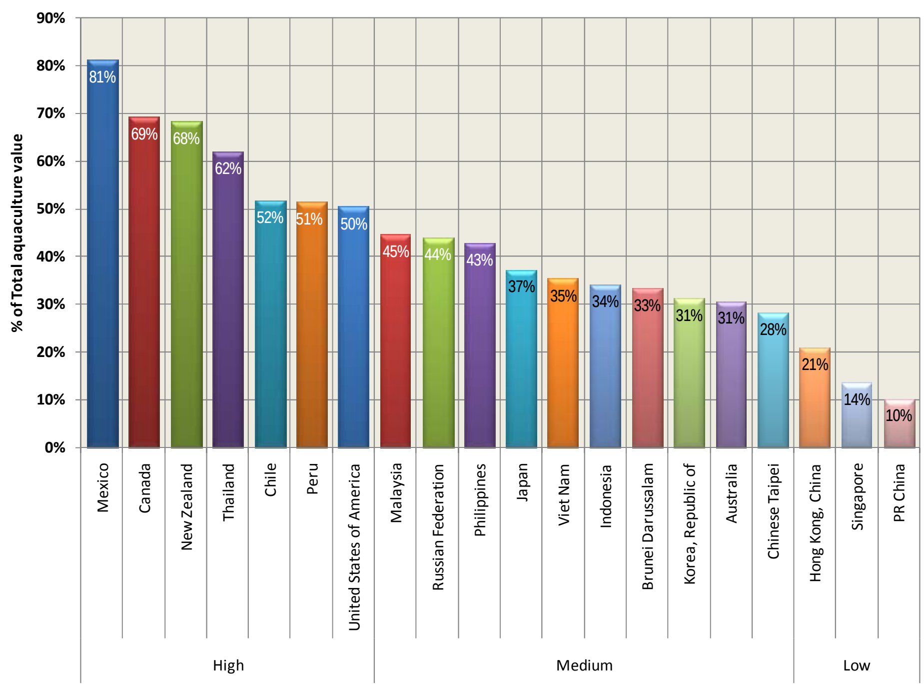
Five economies have a medium level of diversity, with a total 8 or 12 species cultured by each. Only two economies have aquaculture sectors with a low diversity during the period 2000-2006, these are New Zealand with only 4 species being cultured and Papua New Guinea with only 1[3].

Figures 37 and 38 show the level of dependence of aquaculture activity in the APEC region to the one and 3 most important species cultured by each economy. These figures have been constructed under the basis that if 50% or more of the annual value of the aquaculture sector depends on one or three species most important in value terms, the activity for this economy is sought to be highly dependent of these few species. Similarly, if 25% or more but less than 50% of the total annual value of production is dependent on one or three of the most important aquaculture species, the economy is sought to have a medium level of dependence. If less than 25% of the total annual value of aquaculture production depends on one or three of the most important species, it is said to have a low level of dependence on them.

[3] It is important to highlight that during the last part of the period Papua New Guinea showed no aquaculture production.

Accordingly, Figure 37 shows that Mexico´s aquaculture activity is highly dependent on only one specie (Whiteleg shrimp), which generates in average 81% of the total annual value of aquaculture production in the period of analysis. Canada is highly dependent on Atlantic salmon with 69% of total annual value of their aquaculture production and New Zealand is highly dependent New Zealand mussel 68% of their total annual value of production. Other economies with aquaculture sectors highly dependent on one specie are: Thailand (Giant tiger prawn), Chile (Atlantic salmon), Peru (Peruvian calico scallop) and the USA (Channel catfish).

Figure 37 Level of dependence of aquaculture production on one specie in the APEC Region, period 2000-2006



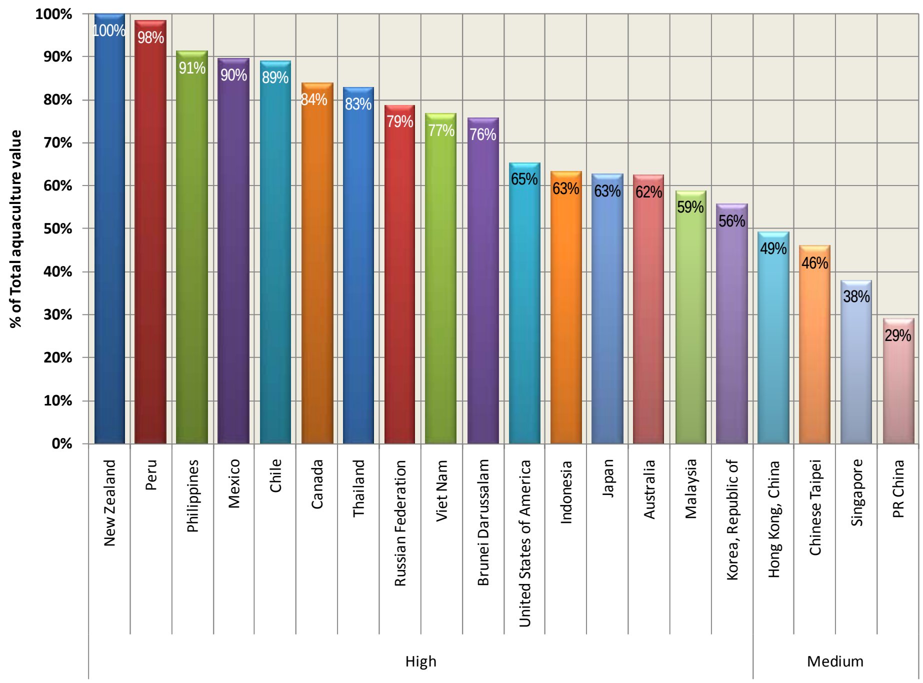
Source: elaborated from FAO FishStat database on aquaculture production

For economies with aquaculture sector with medium levels of dependence on the most important species in value terms, please see Table A22 Appendix II.

Economies with aquaculture sectors presenting a low level of dependence are Hong Kong China, Singapore and PR Chine, with 21%, 14% and 10% of their total annual value dependent of the production of one specie.

Figure 38 presents a similar analysis of dependence for the aquaculture sector of economies pertaining to APEC. As Figure 38 shows that most economies increase in their level of dependence, moving from medium to high dependence and from low to medium dependence. In fact, no economies with low level of dependence are observable under this analysis. All, but one economy (Chinese Taipei) previously classified as having a medium level of dependence are now highly dependent. In the high range New Zealand, Peru and the Philippines have the most dependent aquaculture sectors on three species in the APEC region. Simultaneously, Hong Kong China, Singapore and PR China may now be seen as having aquaculture sectors with a medium level of dependence on three species. Please see Table A22, Appendix II for more details.

Figure 38 Level of dependence of aquaculture production on three specie in the APEC Region, period 2000-2006



Source: elaborated from FAO FishStat database on aquaculture production

2.2 Institutional settings and legislation by economies and group of species

Like every professor's assignment, this one sounded simple: "Describe the international elements of sustainable aquaculture." The subject is more complex than it appears. This chapter collects material that is easily available to any reader with Internet access. The chapter is written to support the idea of a regional aquaculture network. Composed of government experts, communicating openly with aquaculture industry experts, and drawing on the expertise and unique problem-solving abilities of the international organizations described in the chapter, the network can help the region make the transition to sustainable aquaculture smoothly, effectively and quickly.

In aquaculture, many unseen problems including potential international trade conflicts lurk below the surface. Those problems have not stopped hundreds of authors from writing dozens of books on how to start, increase, improve, make sustainable – how to conduct every aspect of aquaculture. For example, long-time FAO aquaculture expert Colin Nash, now retired and living in the United States, in his book, *Aquaculture Sector Planning and Management*, describes 12 elements that we should consider in planning aquaculture development. They are:

- DEVELOPMENT OBJECTIVES
- STOCKTAKING / DIAGNOSTIC SURVEY
- DEMAND AND SUPPLY PROJECTIONS
- SETTING TARGETS AND ALLOCATING RESOURCES
- CHOICE OF STRATEGIES
- CHOICE OF POLICY, INSTRUMENTS, PROJECTS
- RESEARCH ON TECHNICAL INFORMATION
- SOURCES OF EXPERTISE
- TRAINING AND EDUCATION PROGRAM
- BUDGET PLAN (INCLUDING FUNDING SOURCES)
- ORGANIZATIONAL CHANGES
- MONITOR / REPORT / CONTROL SYSTEMS

Over the past several decades, many papers and studies have examined each of those elements of aquaculture development in detail. This section of the paper will NOT repeat that work. The international elements section of this paper will briefly describe international aquaculture-related organizations at the global, regional and bilateral levels. It will attempt to convince readers that there is merit in, and need for, a networked approach to aquaculture in the Americas. It will make some suggestions and give examples of how a network might be a cost-effective stimulus to aquaculture development in the region.

In the case of the APEC Economies, the level of development of aquaculture as a socio-economic activity differs widely from one Economy to the next. Emerging economic powers like Viet Nam have advanced aquaculture industries. Established market states like the United States are trying to increase domestic aquaculture, but growth has been slow.

This project has as its basis the idea that aquaculture in all of APEC, including in the Americas, should be conducted on a sustainable basis. "Sustainable aquaculture" means different things to different people, but there is no shortage of interest in aquaculture by international intergovernmental institutions and organizations.

2.2.1 Global Intergovernmental Organizations

This section will explore the international components of aquaculture. To do that, we should look at the main "institutions," most often treaties or agreements, or other arrangements between States, that have a bearing on aquaculture and on trade in aquaculture products. The first group we will look at are known as "specialized agencies" within the United Nations family of international organizations.

Food and Agriculture Organization (FAO). The FAO recently reorganized and renamed its fisheries department, which is now called the Department of Fisheries and Aquaculture. The FAO website contains the following statement about the Department of Fisheries and Aquaculture: *The mission of the Fisheries and Aquaculture Department of FAO is to facilitate and secure the long-term sustainable development and utilization of the world's fisheries and aquaculture. FAO is acutely aware of the fundamental social and economic role played by these two sectors in:*

1. Meeting global and national sustainable food security.
2. Providing self and paid employment for fishing and aquaculture related communities as a means of alleviating poverty in these fishing communities and stemming rural/urban drift.
3. Contributing to national and international trade.
4. Generating national income.

Underpinning these basic social and economic objectives is the requirement for fisheries and aquaculture to be responsibly managed. This implies preventing overfishing, promoting sustainable aquaculture, co-ordination and delivery of effective research and extension and the empowerment of people, especially women tasks for which many FAO Members are not fully prepared. The Fisheries and Aquaculture Department therefore provides, on the request of Members, technical assistance in all aspects of fisheries and aquaculture management and development. Additional information about the FAO can be found on its website: http://www.fao.org/fishery/

Participation in FAO Committee on Fisheries (COFI) deliberations gives all countries, developed and developing, a voice in the technical discussions that attempt to explain with greater clarity what is meant by concepts like "sustainable aquaculture." Aquaculture "certification guidelines" are on the agenda for a COFI Subcommittee on Aquaculture meeting hosted by Chile in Puerto Varas the week of October 6-10, 2008.

FAO also administers a Technical Cooperation Program (TCP) that supports the FAO Member Nations through small projects which address specific problems in the agriculture, fisheries and forestry sectors. The aim of a TCP project is to produce tangible and immediate results in the battle against hunger and to catalyze long-term changes. Since its creation in 1976, the TCP has funded projects worth more than US$ 1.1 billion.

The TCP mobilizes the technical expertise of the entire Organization. It is managed by FAO's Technical Cooperation Department and is coordinated by the **Technical Cooperation Program Service (TCOT)**. TCOT works in close cooperation with FAO's technical and operational units at its headquarters in Rome, and in the decentralized offices, to identify the most appropriate solutions to the problems faced by governments, national institutions and the beneficiary rural communities.

The Technical Cooperation Program is one of FAO's tools for contributing to the achievement of the UN Millennium Development Goals and particularly the goal of eradicating extreme poverty and hunger. This information is taken from the TCP website at (http://www.fao.org/tc/tcp).

World Trade Organization (WTO). First, trade in aquaculture and aquaculture products relies on the global trading system to make sure that products from one country can compete in the market places of other countries. The website of the World Trade Organization (WTO) states that it "…is the only global international organization dealing with the rules of trade between nations. At its heart are the WTO agreements, negotiated and signed by the bulk of the world's trading nations and ratified in their parliaments. The goal is to help producers of goods and services, exporters, and importers conduct their business." The WTO is also the international forum that "disciplines" the trading system. If one state imposes an unfair trade practice on another state, that practice can be challenged through processes described in the WTO agreements. The WTO website (http://www.wto.org) describes the organization more fully.

World Animal Health Organization (OIE). This treaty-based organization, perhaps better known by its French acronym (which stood for *Office International des Epizooties*) was renamed several years ago. It is responsible for improving animal health worldwide. It's expertise in terrestrial animal health is well known; in some regions and in some countries, its veterinary experts are not as familiar with aquatic and marine animals and their diseases. OIE has 172 member countries and territories and offices on every continent. By joining the organization, member countries agree to report, through designated veterinary officials, animal health problems and disease outbreaks. OIE helps coordinate the global response to disease outbreaks like bird flu that have been reported widely in the press in recent years. When OIE members do not report disease outbreaks, they can spread rapidly, affecting animals in other countries. Reporting of a severe shrimp virus outbreak several years ago was delayed and several countries lost a high percentage of their shrimp crops. The OIE website (http://www.oie.int) is a useful resource.

World Health Organization (WHO). The World Health Organization "…is the directing and coordinating authority for health within the United Nations system. It is responsible for providing leadership on global health matters, shaping the health research agenda, setting norms and standards, articulating evidence-based policy options, providing technical support to countries and monitoring and assessing health trends," its website (http://www.who.int) says.

***Codex Alimentarius* (Codex).** The Codex website says that the "…Codex Alimentarius Commission was created in 1963 by FAO and WHO to develop food standards, guidelines and related texts such as codes of practice under the Joint FAO/WHO Food Standards Program. The main purposes of this Program are protecting health of the consumers and ensuring fair trade practices in the food trade, and promoting coordination of all food standards work undertaken by international governmental and non-governmental organizations." The work of this organization, in terms of food standards-setting, is important, quite technical, and serves as a good source of technical expertise in cases where it appears that food safety may be an issue. Its website is at: (http://www.codexalimentarius.net)

Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP). The Technical Secretaries of the eight UN agencies IMO, FAO, UNESCO-IOC, WMO, IAEA, UN, UNEP, and UNIDO, along with the Administrative Secretary, nominated by IMO which currently serves as the Administrative Secretariat, form the Executive Board of GESAMP. The Executive Board meets together with the Chairperson and Vice-Chairperson of GESAMP as the Executive Committee which is responsible for the general oversight of GESAMP as well as planning and approving the GESAMP budget and work plan, selecting the GESAMP Members from the Pool of Experts, proposing provisional agendas for GESAMP sessions, and adopting terms of reference for its working groups, as described more fully on the GESAMP website: http://gesamp.net.

GESAMP actively seeks to work with Partner Organizations through co-sponsorship of Working Groups and other activities. Governments and organizations may initiate partnerships, for example by proposing potential work for GESAMP. The preferred arrangement for partnership activities is to use the GESAMP structure and to produce products under the GESAMP banner, with partner organizations as full and equal co-sponsors. If a Working Group is co-sponsored by both GESAMP and external partner organizations, it is preferred that Working Group Members be selected from the GESAMP pool and the output published in GESAMP Reports and Studies. Nevertheless partner organizations act equally with the Executive Committee in the selection of Working Group members, development of terms of reference and work plan, etc., and receive full recognition as equal co-sponsors of the Working Group. The primary considerations for GESAMP in establishing partnerships are making GESAMP's activities inclusive and safeguarding the scientific credibility and independence of GESAMP's advice. Individual groups or supporting organizations may similarly support GESAMP's work while not actively participating in it through contributions to the GESAMP Trust Fund or by other means. Such supporters are prominently identified on the GESAMP web site and in promotional materials.

World Customs Organization (WCO). The World Customs Organization (WCO) is the only intergovernmental organization exclusively focused on Customs matters. With its worldwide membership, the WCO is now recognized as the voice of the global Customs community. It is particularly noted for its work in areas covering the development of global standards, the simplification and harmonization of Customs procedures, trade supply chain security, the facilitation of international trade, the enhancement of Customs enforcement and compliance activities, anti-counterfeiting and piracy initiatives, public-private partnerships, integrity promotion, and sustainable global Customs capacity building programs. The WCO also maintains the international Harmonized System goods nomenclature, and administers the technical aspects of the WTO Agreements on Customs Valuation and Rules of Origin. WCO's website is at: http://www.wcoomd.org

The United Nations Environmental Program (UNEP). UNEP's website (http://www.unep.org) states that its mission is to provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations. UNEP's most valuable contributions in fisheries and aquaculture have involved case studies of countries or regions tackling environmental problems related to or arising from fishing and aquaculture.

The Organization for Economic Cooperation and Development (OECD*).* The OECD provides a setting in which governments can compare policy experiences, seek answers to common problems, identify good practices, and co-ordinate domestic and international policies. The mandate of the OECD is broad, covering economic, environmental, and social issues. It is a forum where peer pressure can act as a powerful incentive to improve policy and implement "soft law" — non-binding instruments that can occasionally lead to binding treaties.

Exchanges between OECD governments flow from information and analysis provided by a secretariat in Paris. The secretariat collects data, monitors trends, and analyses and forecasts economic developments. It also researches social changes or evolving patterns in trade, environment, agriculture, technology, taxation and other areas. The OECD is also known as a premium statistical agency, as it publishes highly-comparable statistics on a very wide number of subjects.

Over the past several decades, the OECD has analyzed a range of economic, social, and environmental issues while further deepening its engagement with business, trade unions and other representatives of civil society. Collaboration at the OECD regarding taxation, for example, have fostered the growth of a global web of bilateral tax treaties. The OECD Fisheries Committee website is password protected.

International Labor Organization (ILO). According to Wikipedia, the ILO is a specialized agency of the United Nations that deals with labour issues. Its headquarters are in Geneva, Switzerland. Its secretariat — the people who are employed by it throughout the world — is known as the International Labour Office. One of the principal functions of the ILO is setting international labor standards through the adoption of conventions and recommendations covering a broad spectrum of labor-related subjects and which, together, are sometimes referred to as the International Labor Code. The topics covered include a wide range of issues, from freedom of association to health and safety at work, working conditions in the maritime sector, night work, discrimination, child labor, and forced labor. Texts of ILO conventions and information on its activities can be found on its website at (http://www.ilo.org).

The International Union for Conservation of Nature (IUCN). IUCN helps the world find pragmatic solutions to our most pressing environment and development challenges. It supports scientific research, manages field projects all over the world and brings governments, non-government organizations, United Nations agencies, companies and local communities together to develop and implement policy, laws and best practice.

IUCN is the world's oldest and largest global environmental network - a democratic membership union with more than 1,000 government and NGO member organizations, and almost 11,000 volunteer scientists in more than 160 countries.

IUCN's work is supported by over 1,000 professional staff in 60 offices and hundreds of partners in public, NGO and private sectors around the world. The Union's headquarters are located in Gland, near Geneva, in Switzerland.

In October 2007, IUCN released the first in the series of "Guidelines for the Sustainable Development of Mediterranean Aquaculture" targeted at decision-makers, scientists and producers. IUCN's website is at (http://www.iucn.org).

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). According to its website (http://www.cites.org), "CITES is an international agreement between governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival.

Widespread information nowadays about the endangered status of many prominent species, such as the tiger and elephants, might make the need for such a convention seem obvious. But at the time when the ideas for CITES were first formed, in the 1960s, international discussion of the regulation of wildlife trade for conservation purposes was something relatively new. With hindsight, the need for CITES is clear.

Annually, international wildlife trade is estimated to be worth billions of dollars and to include hundreds of millions of plant and animal specimens. The trade is diverse, ranging from live animals and plants to a vast array of wildlife products derived from them, including food products, exotic leather goods, wooden musical instruments, timber, tourist curios and medicines. Levels of exploitation of some animal and plant species are high and the trade in them, together with other factors, such as habitat loss, is capable of heavily depleting their populations and even bringing some species close to extinction. Many wildlife species in trade are not endangered, but the existence of an agreement to ensure the sustainability of the trade is important in order to safeguard these resources for the future.

Because the trade in wild animals and plants crosses borders between countries, the effort to regulate it requires international cooperation to safeguard certain species from over-exploitation. CITES was conceived in the spirit of such cooperation. Today, it accords varying degrees of protection to more than 30,000 species of animals and plants, whether they are traded as live specimens, fur coats or dried herbs."

"CITES is an international agreement to which States (countries) adhere voluntarily. States that have agreed to be bound by the Convention ('joined' CITES) are known as Parties. Although CITES is legally binding on the Parties – in other words they have to implement the Convention – it does not take the place of national laws. Rather it provides a framework to be respected by each Party, which has to adopt its own domestic legislation to ensure that CITES is implemented at the national level."

2.2.2 Regional Intergovernmental Organizations

A second group of intergovernmental bodies functions at the regional level. Examples of these regional organizations in the Americas include several regional fishery management organizations (RFMOs) for capture fisheries and economic development-related organizations whose mandates may include aquaculture development or cooperation.

The United Nations website, under the section covering the work of the Division of Oceans and the Law of the Sea (DOALOS), lists many regional organizations throughout the world that engage in fisheries or aquaculture management. This website is at: http://www.un.org/Depts/los/Links/IGO-links-fish.htm . The table on that website lists the following organizations; yellow highlights indicate organizations that may be relevant to this project:

Table 4 Regional Fisheries Bodies established under the auspices of the Food and Agriculture Organization (FAO) of the United Nations, dealing with marine fisheries

	APFIC	Asia-Pacific Fishery Commission
	CECAF	Fishery Committee for the Eastern Central Atlantic
	GFCM	General Fisheries Commission for the Mediterranean
	IOFC	Indian Ocean Fishery Commission

	IOTC	Indian Ocean Tuna Commission
	WECAFC	Western-Central Atlantic Fishery Commission

Table 5 Regional Fisheries Bodies (Non-FAO) (as listed in the FAO Fisheries Circular No. 940)

(link to FAO Directory of Fisheries, Aquaculture and Related Internet Sites)		
	COREP	Comité Régional des Pêches du Golfe de Guinée *(currently no web site)*
	CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
	CCSBT	Commission for the Conservation of Southern Bluefin Tuna
	CSRP	Commission Sous-Régionale des Pêches *(currently no web site)*
	FFA	Forum Fisheries Agency (of the South Pacific Forum)
	IATTC	Inter-American Tropical Tuna Commission
	IBSFC	International Baltic Sea Fishery Commission
	ICCAT	International Commission for the Conservation of Atlantic Tunas
	IPHC	International Pacific Halibut Commission
	IWC	International Whaling Commission
	CTMFM	Joint Technical Commission for the Argentina/Uruguay Maritime Boundary *(currently no web site)*

(link to FAO Directory of Fisheries, Aquaculture and Related Internet Sites)		
	OLDEPESCA	Latin American Fisheries Development Organization
	NEAFC	North-East Atlantic Fisheries Commission
	NPAFC	North Pacific Anadromous Fish Commission
	PICES	North Pacific Marine Science Organization
	NAFO	Northwest Atlantic Fisheries Organization
	NASCO	North Atlantic Salmon Conservation Organization
	PSC	Pacific Salmon Commission
	CPPS	Permanent Commission for the South Pacific
	SPC	South Pacific Commission
	SPF	South Pacific Forum Secretariat

The Western and Central Atlantic Fisheries Commission (WECAFC). Living marine resources are critical for human well-being in the Wider Caribbean region. These are mainly fisheries resources which provide food and employment for many thousands of coastal inhabitants. Other non-exploited resources such as reef corals are also important in sustaining tourism. Many of these resources are transboundary and require collaboration for effective governance. The fact that many of the fisheries are small-scale makes this even more difficult. In this paper we address the governance needs for marine systems in the Wider Caribbean region through the evaluation of Institutional arrangements for governance (IAG) of transboundary marine resources. We observe that IAG in the region are weak or lacking, and issues of scale are the most challenging ones for this region given the range in size, development and capacity of the countries in the area. Existing organizations will need to be adapted for governance having been designed for other primary purposes. For instance, fisheries organizations are most well established but lack decision-making functions. There are no large fishery stocks from which to derive revenues to support a regional fisheries management organization. Improved institutions must be tailored to Caribbean reality. Alternative models must be considered and evaluated with concerns such as cost, equitability and best use of expertise in mind. This paper is not prescriptive but outlines options and approaches for adequate regional governance of fisheries, including some pros and cons. There will be the need for a considerable amount of developmental work before feasible mechanisms can be proposed.

La Organización del Sector Pesquero y Acuícola del Istmo Centroamericano (OSPESCA). OSPESCA is an inter-governmental organization of the fisheries and aquaculture authorities of Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama, the countries which constitute the Central American Isthmus. The purpose of OSPESCA is to promote the coordinated and sustainable development of fisheries and aquaculture as part of the integration process, pursuant to the Fisheries and Aquaculture Integration Policy of the Central American Isthmus. More information about OSPESCA can be found at:

http://webserv-mida.mida.gob.pa/MIDA/PREPAC/PDF/QUE%20ES%20OSPESCA.pdf

OSPESCA is not listed on the DOALOS website, but it has been engaged in the coordination of aquaculture projects in the region.

Latin American Organization for Fisheries Development (OLDEPESCA). The main purpose of the organization is to meet Latin American food requirements adequately, making use of Latin American fishery resource potential for the benefit of Latin American peoples, by concerted action in promoting the constant development of the countries and the permanent strengthening of regional cooperation in this sector, according to the FAO website (http://www.fao.org/fishery/rfb/oldepesca) which also describes the organization's objectives, strategies, membership and languages, as shown below.

Objectives	

The general objectives of the Organization are:

- to promote adequate utilization of fishery resources, preserving the marine and freshwater environment through the application of rational policies for the conservation of resources;
- to encourage and strengthen the Latin American cooperation in the development of the rational exploitation of sea and freshwater fishery resources, for the benefit of the peoples in the region;
- to increase substantially a food supply of sufficient nutritional value, the prices, preparation and presentation of which are in keeping with the needs of the low-income inhabitants of the region;
- to increase in the same manner, consumption of marine and freshwater products in the region;
- to encourage, similarly, export diversification and expansion;
- to promote marketing systems to expand the regional exchange of products of the sector;
- to promote generation of jobs and improvement of incomes, through greater social and economic development of the communities related to the fish of the region;

- to improve and strengthen the productive, institutional, organizational and human resources capacity of the sector;
- to promote and organize utilization of the joint negotiating capacity of the Latin American region, as well as to determine, identify and channel international, technical and financial cooperation, through concrete regional coordination and cooperation within the scope of the sector.

Strategies

In order to attain its objectives, OLDEPESCA carries out activities in the following areas of fisheries:

- in the Area of Research on fishery resources, it fosters joint actions for their rational utilization and adequate conservation;
- in the Area of Exploitation of fishery resources, industrialization and physical support infrastructure, it arranges for multilateral activities to be carried out for the exploitation of fishery resources of regional interest and for providing incentives for the industrializations of sea and freshwater products;
- in the Area of Aquaculture, it fosters and develops said activities aimed at expanding fishery production in marine and inland waters;
- in the Area of Technological development, it encourages production, adaptation, promotion and dissemination of technologies suitable to regional condition in order to enhance production and at the same time preserving the marine environment and protecting resources;
- in the Marketing Area, it establishes the mechanisms necessary for improving marketing conditions of Latin American fishery products and for making them more accessible to the regional consumer and more competitive in export markets;
- in the Training Area, it encourages specialization at all levels and stages of the fishery activity, with emphasis on artisanal fishing, according to national or multinational program requirements;
- in the Area of International Cooperation, it identifies and channels the international technical and financial cooperation required for complying with the objectives of the organization and implementing the specific projects.

Members

Belice Bolivia Costa Rica Cuba Ecuador El Salvador Guatemala Guyana Honduras Mexico Nicaragua Panama Peru Venezuela

Languages

Spanish, English

La Comisión Permanente del Pacífico Sur (CPPS). The South Pacific Permanent Commission (CPPS) is the Regional Maritime Agency that coordinates the maritime policies of its member countries: Chile, Colombia, Ecuador and Peru. Founded on August 18 1952 with the 'Declaration on Maritime Zone' signed in Santiago by the governments of Chile, Ecuador and Peru. Columbia joined the organization on Aug. 9, 1979. For more information, see the CPPS website: (http://www.cpps-int.org) .

Inter-American Tropical Tuna Commission (IATTC). This is a regional fishery management organization (RFMO) for tuna capture fisheries. It has begun to see development of "tuna ranching," a form of aquaculture in which juvenile tunas are captured, put into pens and grown to market size. Website: (http://www.iattc.org).

International Commission for the Conservation of Atlantic Tunas (ICCAT). ICCAT is another tuna RFMO where capture of juvenile tunas for tuna ranching operations is causing fishery management problems. Website: (http://www.iccat.int).

Asia-Pacific Economic Cooperation (APEC). APEC is an economic integration and trade facilitation organization consisting of 21 “Economies” around the Pacific Rim. The APEC Fisheries Working Group (FWG) and the APEC Marine Resource Conservation Working Group (MRCWG) have undertaken several aquaculture-related projects during the past 10 years. APEC centrally funds projects, usually in amounts from $50,000 to as much as $100,000 (US), that contribute to economic development or to trade facilitation among APEC Economies. The October 2-3 Puerto Montt workshop is part of a MRCWG project to describe sustainable aquaculture development in APEC. It flows from earlier FWG projects that sought to establish a regional “Aquaculture Network for the Americas,” starting with the 5 APEC Economies in the Americas (Chile, Peru, Mexico, the United States and Canada) and two additional aquaculture producers in the region, Brazil and Ecuador. The APEC website is at (http://www.apec.org).

The Inter-American Institute for Cooperation on Agriculture (IICA). IICA is a specialized agency of the Inter-American System, and its purposes are to encourage and support the efforts of its Member States to achieve agricultural development and well-being for rural populations. For over 60 years, IICA is an excellent model for agricultural development. Complete information about IICA is available on its website: http://www.iica.int .

2.2.3 Bilateral Aquaculture Arrangements

The recent round of bilateral (and regional) “free trade agreement” negotiations may offer opportunities for aquaculture development. Without listing every existing bilateral arrangement, I will list three:

US-Chile Free Trade Agreement: This agreement contains an “environment” chapter, which provides scope (but no funding!) for bilateral cooperation for environment-related projects. It could serve as the umbrella under which aquaculture interests (business or government) in the two countries cooperated on an aquaculture project.

Spain’s “SPADA” Project. One press account suggests that Spain may be involved in a EURO 12 million bilateral assistance program to countries in South America interested in aquaculture development. It is unclear how these funds will be used.

US-Central America Free Trade Agreement (CAFTA). While none of the current ANA countries are located in the area covered by this agreement, it is an example of the use of a bilateral agreement to leverage bilateral donor assistance to solve fisheries problems. USAID is expected to launch a study designed to find alternative income producing activities for spiny lobster fishermen who will be leaving the fishery in order to ensure that it is not overfished. They fishermen in question live in a remote area on the border of Honduras and Nicaragua and there is currently no employment opportunity there.

2.2.4 Non-Governmental Aquaculture Organizations

An agriculture business website (http://www.Agricultureb2b.com) lists a number of aquaculture organizations around the world that will give readers a flavor for non-governmental aquaculture cooperation that may also serve as models for regional private sector approaches to aquaculture development.

2.2.4.1 Salmon of the Americas

Salmon of the Americas is an organization of salmon-producing companies in Canada, Chile and the United States whose mission is to improve health, awareness and dining enjoyment of consumers in North America by providing timely, complete, accurate and insightful information about salmon on behalf of the member companies. Location: United States

2.2.4.2 World Aquaculture Society

The web site of the World Aquaculture Society (WAS), an international non-profit society with over 3,000 members in 94 countries. Founded in 1970, the primary focus of WAS is to improve communication and information exchange within the diverse global aquaculture community. The WAS has international chapters in the Asian Pacific region, Latin America, the US and Japan, as well as formal associations with many other aquaculture organizations around the world.

Location: United States, Louisiana, Baton Rouge

2.2.4.3 Aquaculture Certification Council

ACC certifies responsible production practices and food safety at shrimp farms, processing plants and other aquaculture facilities around the world in a process-oriented certification for seafood buyers.

Location: United States, Washington, Kirkland

2.2.4.4 BC Salmon Farmers' Association

The Web site of the BC Salmon Farmers Association (BCSFA) Â– the voice of the province's environmentally sustainable salmon farming industry. The BCSFA is based in Campbell River, British Columbia Â– a coastal community on the northern half of Vancouver Island.

Location: Canada, British Columbia, Campbell River

2.2.4.5 Geothermal Aquaculture Research Foundation Inc.

We teach coral farming online so that we can help save the coral reefs from over collection. Learn to grow coral. As people see reef aquariums they will become interested in saving the coral reefs.

Location: United States, Idaho, Boise

2.2.4.6 American Tilapia Association

The objective of the American Tilapia Association is to support and facilitate the growth of Tilapia production and consumption within the United States. We are a non-profit organization with goals in education, member information and networking, government interactions and support for research. We welcome the contributions of any information on Tilapia culture, marketing and development from around the world for inclusion in our regular newsletters.

Location: United States, West Virginia, Charles Town

2.2.4.7 Aquaculture Council of Western Australia

Aquaculture Council of Western Australia - Aquaculture resource site with the latest research industry news directories of jobs, business and investment opportunities consultants suppliers and environment issues.

Location: Australia, Western Australia, Osborne Park

2.2.4.8 California Aquaculture Association

The California Aquaculture Association has served the aquaculture industry in California since 1970. CAA is a producer-oriented non-profit trade association open to all serious aqua culturists interested in the production of fish, shellfish, invertebrates or plants in marine, brackish or freshwater. CAA members produce over eighty percent of California's aquaculture products in an industry with farm-site values of about $83,000,000.

Location: United States, California

2.2.4.9 Global Aquaculture Alliance

The Global Aquaculture Alliance is an international, nonprofit trade association dedicated to advancing environmentally and socially responsible aquaculture. GAA recognizes that aquaculture - the culture and farming of fish, shellfish and other aquatic organisms - is the only sustainable means of increasing seafood supply to meet growing food needs. GAA therefore promotes best management practices for sustainable aquaculture through its Responsible Aquaculture Program, conferences and other activities.

Location: United States, Missouri, St. Louis

2.2.4.10 Pacific Coast Shellfish Growers Association

Pacific Coast Shellfish Growers Association: the oldest shellfish growers association on the West Coast of the United States. The Pacific Coast Shellfish Growers Association represents molluscan shellfish growers from Alaska, Hawaii, California, Oregon and Washington, growing many varieties of Oysters, Mussels, Clams and Geoducks.

Location: United States, Washington, Olympia

2.2.4.11 Aquaculture Association of Canada Home Page

The goal of the Aquaculture Association of Canada is to foster an aquaculture industry in Canada, to promote the study of aquaculture and related science in Canada, to gather and disseminate information relating to aquaculture, and to create public awareness and understanding of aquaculture.

Location: Canada, Newfoundland, St. John's

2.2.4.12 AquaTT UETP Ltd.

AquaTT is a network of co-operating university and industry members involved in the aquaculture sector in Europe. The network supports the aquaculture industry through the provision of support services and participation in EU projects and programs in the areas of education, training and technology transfer.

Location: Ireland, Dublin, Dublin

2.2.4.13 Colorado Aquaculture Association

We promote and support fish farming and aquaculture development in Colorado and elsewhere. The CAA maintains an active membership of both producers and suppliers of products and services to the aquaculture and fish farming industry. We encourage your membership and support as either an active member or subscribing member.

Location: United States, Colorado, Estes Park

2.2.4.14 Indian Ocean Tuna Commission

The Indian Ocean Tuna Commission (IOTC) is an intergovernmental organization mandated to manage tuna and tuna-like species in the Indian Ocean and adjacent seas. Its objective is to promote cooperation among its Members with a view to ensuring, through appropriate management, the conservation and optimum utilization of stocks and encouraging sustainable development of fisheries based on such stocks.

Location: Seychelles, Mahe, Victoria

2.2.4.15 Polish Fishery Association

We provide information concerning polish aquaculture, freshwater fish farming, farming equipment, feed producers, fish processing plants. Location: Poland

2.2.4.16 Aquaculture Association of Southern Africa

The Aquaculture Association of Southern Africa (AASA) was established in the late 1980's in order to represent the interest of the then fledgling aquaculture industry in Southern Africa. The Association has since developed into a structure with representation from the various sectors contributing towards the aquaculture industry of the region, including marine species such as oysters, mussels, abalone and prawns; freshwater species such as trout, catfish, tilapia, ornamental fishes; as well as service providers such as feed companies, equipment suppliers and veterinary services.

Location: South Africa, Matieland

2.2.4.17 Australian Prawn Farmers Association

Australian Prawn Farmers Association - Prawn farming information, news and statistics. The Australian Prawn Farmer's Association (APFA) was formed in 1993 to represent the interests and foster the development of the Australian prawn farming industry. The Association is a key contact for investors, new farmers and firms wishing to do business with the Australian prawn farming sector.

Location: Australia, Queensland, Brisbane City

2.2.4.18 European Aquaculture Society

Objectives of The European Aquaculture Society: To promote contacts between all involved or interested in marine and freshwater aquaculture; To facilitate the circulation of aquaculture related information; To promote the sponsorship of multi-disciplinary research concerning aquaculture; To enhance cooperation among governmental, scientific and commercial organizations and individuals on all matters dealing with aquaculture.

Location: Belgium, Flanders, Ostende.

2.2.4.19 Japan International Food & Aquaculture Society

An association of Aquaculture Companies for the purposes of researching and developing land based aquaculture systems, and new food production technologies. Includes information on super-intensive shrimp production methods.

Location: Japan

2.2.5 Recommendations and Conclusions

There are too many international organizations involved in aquaculture "governance." Each one requires a different set of in-depth subject matter knowledge. Using Nash's 12 elements of aquaculture planning, we can explore how a regional network can bring sustainable aquaculture development to the Americas.

2.2.5.1 Development objectives

In this region, aquaculture development objectives include safe, healthy employment and poverty alleviation, providing market access for safe, wholesome products, control of aquatic animal health issues (disease outbreaks), control of effluents from aquaculture and processing operations, and proper planning to avoid other harmful environmental impacts of aquaculture operations. Referring to our long list of international organizations, labor issues like forced labor, child labor, and trafficking in persons are areas attracting much interest in the international community. They can impact trade with certain markets. Information on tackling these problems is available through the International Labor Organization (ILO). Food safety standards are set by Codex Alimentarius; international trading rules that keep those standards from being used as barriers to trade are administered and "disciplined" (enforced) by the World Trade Organization (WTO). Animal health issues are addressed by the International Animal Health Organization (OIE), through a designated veterinary officer in each country. FAO's Fisheries and Aquaculture Management Division staff have considerable expertise in, and information on, planning the location and design of aquaculture operations to minimize the environmental impacts of aquaculture.

Properly coordinated, perhaps through a regional network, it should be possible to use this international expertise to set the stage for the expansion of aquaculture in the Americas. In some areas, a formal arrangement like OSPESCA may be required. In others, in informal arrangement, such as the "Aquaculture Network for the Americas (ANA)," may be a good starting point. ANA members expect to sign a text that will officially start this network during the week of October 6-10 in Puerto Varas, Chile.

Nash reminds his readers that developing a single aquaculture plan for a whole country must take into account regional differences within the country in geography, in political realities, in climate, in regulatory regimes, etc. That reminder is valid in the larger regional context, where a region consists of many countries. "Economic objectives may have to conform to social objectives and political realities, even at the expense of economic efficiency," as Nash says.

2.2.5.2 Stocktaking / diagnostic survey

This paper will take a major step towards this element of aquaculture planning.

2.2.5.3 Demand and supply projections

Understanding domestic and international demand for a product BEFORE starting large scale production is a fundamental element of a business plan! FAO publications such as INFOFISH provide frequent and regular global market information across the range of fish and fish products, be they produced from capture fisheries or through aquaculture. The extent to which business planning is done by private companies or by governments differs across the region. But reasonable comprehensive market information is available often by subscription.

Estimating the supply of raw materials (seed, feed, clean water) and of the space for aquaculture operations, either on land or in the water, can be more complicated. Understanding how and where aquaculture operations developed in other parts of the world, through literature searches of FAO materials and perhaps UNEP documents and case studies, can improve efficiency. It is no coincidence that the salmon farming operations near Puerto Montt take place in an area that looks very similar to the coast of Norway, where there are also salmon farming operations.

2.2.5.4 Setting targets and allocating resources

A simple plan, with a few clearly stated objectives is easier to understand and thus has a better chance of success. Setting an aquaculture production target will be difficult at best. In the context of a regional aquaculture network, targets must be achievable and fair to all members of the network.

Financial and human resources can come from within the region and from outside the region. A network can coordinate the aquaculture activities of member governments, avoiding duplication of effort and achieving cost savings. A network can also coordinate bilateral assistance from outside the region. Sweden contributes bilateral fisheries assistance to Nicaragua; if an element of that assistance supported aquaculture development, if Nicaragua were a member of a regional aquaculture network, and if that outputs from that assistance could be directed towards the objectives of the network, the whole region could benefit from Sweden's bilateral assistance. Similarly, OSPESCA or OLDEPESCA, or another existing regional organization that have "aquaculture development" as an objective, can achieve that objective by contributing to the success of a regional aquaculture network. At the same time, international organizations have assistance funding to solve specific problems in specific countries. FAO's term for this type of assistance is a "technical cooperation project," or TCP. The results of a given TCP could be shared among network members. All of these suggestions will require a high degree of cooperation and openness among members of the aquaculture network in the region.

2.2.5.5 Choice of strategies

Why is this network strategy the approach the authors recommend? What indication is there that it can work? The answers to both of those questions can be found in these words: the Network of Aquaculture Centers in Asia-Pacific (NACA). NACA is such a network, it is alive and well and it has solved aquaculture development problems by successfully implementing many of the suggestions that appear in this paper. The NACA model – small, dedicated staff; well-coordinated regional projects; maximum use of web-based communications tools; combining resources from many sources inside and without its member countries – these are the tools NACA has developed, tested, refined and improved over the past 20 years.

2.2.5.6 Choice of policy, instruments, projects

This chapter assumes that the network approach, with its low operational costs and the high potential for successful expansion of aquaculture, is a more effective way towards aquaculture development. We are aware of the more traditional model, upon which much of the agricultural development in the past century was based. That is the model of the Inter-American Institute for Cooperation on Agriculture (IICA). IICA functions as a traditional intergovernmental, treaty based organization. In the view of the authors, the NACA networked approach is easier to develop, fund and operate, and it lends itself to the current situation of aquaculture better than the IICA model.

2.2.5.7 Research on technical information

To be done on a case-by-case basis by and through the network.

2.2.5.8 Sources of expertise

The network approach allows network members to draw on expertise both within and outside the network and network members. A leading shrimp virus expert who lives in Peru can assist shrimp farmers in Mexico through the network. Mexico's oyster culture expert can help colleagues planning oyster culture operations in Chile, etc. But the network can also hold (or attend) workshops and use the internet to distribute the results to network members.

2.2.5.9 Training and education program

NACA is again a useful model for our aquaculture network to follow. NACA hosts frequent "capacity-building" workshops, drawing top talent from academic campuses and from intergovernmental organizations to workshops targeted at specific problems. NACA participants both solve problems and gain experience in how to solve them through these types of workshops. It is easy to envision those kinds of benefits from our network as well.

2.2.5.10 Budget plan (including funding sources)

As discussed above, the network approach must make best use of all sources of funding. Maximum coordination of assistance programs, regardless of the source, for aquaculture development and aquaculture operations should also take place. The success of the network will be measured by its ability to get the most out of every unit of currency that it receives. If network members can receive the same information through participation of one representative in an international meeting, why send six?

2.2.5.11 Organizational changes

Aside from establishing and operating a small staff, network members do not need to make immediate organizational changes at this time. After several years of operation, necessary changes should be considered.

2.2.5.12 Monitor / report / control systems

Upon starting an aquaculture network, members must determine baseline aquaculture data and the network must collect it! A functional system for monitoring and reporting aquaculture development should be developed at the start of network operations as well. Comparison of progress against baseline levels can be used to demonstrate the contribution of the network to aquaculture development in the region over time.

It will also be important to develop a simple governance structure and accounting controls to ensure the financial stability of network operations.

2.2.5.13 Summary

This section of the paper has described a range of international arrangements and organizations that can have an impact on sustainable aquaculture development in the APEC region. Using examples of an existing aquaculture network, NACA, and one that is being started in the Americas, the paper tries to show how international institutions can be engaged at nearly every step in the development of aquaculture at the national and regional level. It also tries to explain how the network approach to sustainable aquaculture development is more efficient and less expensive than pursuing the same development objectives one State at a time.

3 Sustainability, Sustainable Development and Aquaculture

3.1 Sustainability and sustainable development: concepts and current discussion

There has been much debate about the concepts of sustainability and sustainable development over the last 20 years at least. Here, we will briefly review the underlying notions for these concepts and identify one or a mix of them that will satisfy the purposes of this study.

3.1.1 The discussion

In the late 80s, concerned about the world future perspectives (by year 2000), the United Nations assembled a commission of experts to discuss about the environment and development, whose product was a report setting the basis for the discussion on Sustainable Development and which came to be known as “The Brundtland Commission Report”. The main conclusion of this commission was that “*Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs*” (UNDP 1987). Thus, the concept of sustainable development implies that limitations are imposed by the present state of technology and social organizations on environmental resources use and by the biosphere to absorb the effects of human activities. The report also highlights that it is crucial to consider that technology and social organizations can both be managed and improved (UNDP 1987).

Since then, there has been much debate about the concepts and implications of approaches taken with respect to sustainability and sustainable development, from those labeled neoclassical economists or environmental economist to biologists-ecologists and ecological economists.

At the center of the discussion it is the notion and the concept of ***sustainability***, which has been divided into two branches “**weak sustainability**” and “**strong sustainability**”(AASwart Jac 2005; Ayres RU. 1998; Ott 2003; Turner 1992). The first, commonly related to the neoclassical or environmental economists view of the problem and the later, related as the biologists-ecologists and ecological economists view.

In 1991, while addressing an audience of scientist at Woods Hole Institute in Massachusetts, USA, the economist Robert Solow expressed that at the basis of the *notion of sustainability* there is a moral obligation, which is traditionally expressed towards future generations[4] or as intergenerational distributional equity issues (Solow 1991). Important for future reference is to highlight that Solow (1991) also stated that the moral obligation attached to the notion of sustainability should also be understood as an intra-generational distributional equity[5] issue.

Solow further indicated that from a philosophical point of view, nobody can be morally obligated to do things that are not possible to be done and he exemplified with UNESCO’s definition arguing that “if sustainability is defined as the obligation to leave the world as we found it in detail, that is a glib but

[4] Initially expressed in the report of the Brundtland Commission, in 1987

[5] “*The only reason for thinking that sustainability is a problem is that you think that some people are likely to be shortchanged, namely, in the future. Then I think you really are obligated to ask, "Well, is anybody being shortchanged right now?*” (Solow 1991).

essentially unfeasible"[6]. In turn, Solow (1991) suggested an alternative definition for the notion of moral obligation surrounding sustainability, which reads: "it is an obligation to conduct ourselves so that we leave to the future the option or the capacity to be as well off as we are".

At the basis of Solow's definition is the notion that human well being is related to the capacity of creating and maintaining employments that in turn will generate income and hopefully wealth. From the economics point of view, this requires the existence of an enabling environment and a resource base, as well as, access to its use. This, enabling environment and resource base will be both, natural (environment and resources) and man-made (physical productive capital, human resources and technology, financial capital, social infrastructure and equipment, social organizations including institutional and legal setting and other).

Also, from an economic point of view, the notion of human well being and its relation to the satisfaction of human needs, through the use and consumption of services and goods, is related to the notion of choice and substitutability. On the one side, the choice and substitutability between goods and services that will lead to the satisfaction of human needs (basic and non-basic) through present and future use and consumption and on the other side, choice and substitution between production factors (physical capital, human resources, technology, natural resources, the environment and other inputs).

That is why Solow (1991) highlights that under sustainability and the sustainable development context, present generations should carefully consider the resources they leave behind including "*built environment*"(e.g., productive capacity -plants and equipment- and technological knowledge). This author also mentions the need to consider that, in this context resources are "*fungible in a certain sense*" as they can take place of each other. In addition, he highlights that this is "*extremely important because it suggests that we do not owe to the future any particular thing. There is no specific object that the goal of sustainability, the obligation of sustainability, requires us to leave untouched*" (Solow 1991).

With respect to the notion of people's desire for nature, wilderness or unspoiled nature, Solow indicates that it should be included in our policy choices as a component of well being. He added that there is a need to recognize that different amenities are, to some extent, substitutable for one another and that we should be as inclusive as possible in considering them. The above implies that it is perfectly all right to argue for the preservation of a specific specie or landscape, because that is what present generations want but, this should be done on its own sake and not on the mane of sustainability. Therefore, in making policy decisions it is possible to take advantage of the principle of substitutability, remembering that present generations are obligated to leave behind a general capacity to create well being, not any particular thing or natural resource.

Two additional issues analyzed by Solow refer to the fact that present generations hardly know how future generations will act and what would be their set of preferences, which is related to the fact that present discount rates are much higher than what would be set from a social public perspective (concerned with the future) and, to the fact that market mechanisms (supply and demand) does not properly account for the future. This lead Solow to suggest that policy actions should be considered to compensate for present burdening on the environment, which is a way in which present generations

[6] Referring to the UNESCO definition that reads "every generation should leave water, air and soil resources as pure and unpolluted as when it came on earth"

free-ride on the future[7]. Therefore, stating that a correct principle is that when present generations use up some that is irreplaceable (renewable or non-renewable resources or an environmental amenity) they need to provide a substitute of equal value (not necessarily a physical object, that is it could be knowledge).

Robert Solow's view is very important as it is the basis for what was later labeled as "***Weak Sustainability***", which includes the concept of "intergenerational distributional equity", leading to the notion of an obligation to leave behind the capacity to create well being and to give future generations the possibility to be at least as well off as present generations, what is supported by the principle of substitutability in terms of value.

Weak sustainability is seen as the approach of most neo-classical economists or environmental economists and in essence may be summarized in three principles:

1) To leave future generations with the option or capacity to be as well off as we are (i.e., dynamic efficiency principle based on value)
2) Any loss of natural capital should be balanced out by creation of new capital of at least equal value.
3) Natural capital and man-made capital can be seen as substitutes.

On the other side of the road, "***Strong Sustainability***" is seen as the approach of most ecological economists and biologists-ecologists to the sustainability issue. It is also based on a moral obligation for intergenerational distribution which goes from only considering that man-made capital is not a substitute for natural capital but, rather they are compliments, to additionally consider more nature centric views (labeled as environmental sustainability) that makes explicit the inclusion of intrinsic value to nature and non-human needs (AASwart Jac. 2005; Ayres RU. 1998; Callicot 1997; Dobson 1998; Ott. 2003; Özkaynak B. 2004).

In 1996, Herman Daly indicated that Strong sustainability argues that natural systems should be maintained whenever possible and he summarized this approach in two principles (Daly 1996):

1) Critical natural capital should be preserved under all circumstances. Goodstein (1999) specifies what this implies for renewable and non-renewable resources as follows:
    a. For renewable resources it means "keeping the annual off take equal to the annual growth increment (sustainable yield) and it is equivalent to maintenance investment"
    b. For nonrenewable resources, "the general rule would be to deplete non-renewable at a rate equal to the development of renewable substitutes."
2) There is a need to consider that natural capital and man-made capital are compliments rather than substitutes.

[7] It is important to note that Solow (1991) indicates that environmental protection policy will contribute to sustainable development if it comes at the expense of current consumption and not at the expense of investment on adaptations to future capacity.

Konrad Ott (2003) stated that strong sustainability emphasizes three guiding principles: (1) the human sphere is embedded in a natural systems (“biosphere”) and natural limits ought to constrain human actions, (2) artificial or man-made capital can only sometimes be substitute for natural capital and (3) it argues in support of a constant-natural-capital rule.

Based on these principles, the author argues for strong sustainability as the approach to reach a sustainable development which ensures environmental sustainability, base on an additional notion, namely a precautionary principle that ensures a safe minimum standard on nature saving (Ott 2003). This based on the observed multi-functionality of ecosystems which, in conjunction with uncertainty raised from the lack of full comprehension of ecosystems and natural processes[8], speaks in favor of a constant natural capital rule.

Other more nature centric definitions of sustainability have been established by authors like Callicot and Mumford (1997) and Noss (1995). First, from an ecological perspective, sustainability may be understood as the need to meet human needs without compromising the health of the ecosystems (Callicot and Mumford 1997). Second, from a holistic biocentric perspective, sustainability is to be seen as the need to focus on sustaining natural ecosystems and all their components for their own sake and, human uses should be included only when they are entirely compatible with the conservation of native biota and natural processes (Noss 1995).

Furthermore, Swat and van der Windt (2005) based on Dobson (1998), analyzed four principles possible to attach to the sustainability concept, moving from the original strong sustainability to more biocentric perspectives, namely: (1) the Critical Natural Capital conception, (2) Irreversible Nature conception and (3) the Natural Value conception.

1) The Critical Natural Capital conception sees natural capital as critical to human welfare, specifying that if natural capital cannot be replaced by equivalent artificial or man-made capital it should be preserved. This implies that sustainability can be achieved by the combination of three actions: renewal (e.g., forestry), substitution (e.g., oil-based energy for nuclear energy) and protection (e.g., biodiversity as far as it is useful to humanity).
2) The Irreversible Nature conception considers the existence of an irreplaceable intrinsic or non-instrumental value of nature, along with its utility for human populations. It implies, therefore, that biodiversity should be protected or preserved regardless of it utility to humans. That is, the intrinsic value would prevent the pure application of calculation of trade-offs. The above underlines the duty or obligation of present generations to protect nature. It also implies that substitution and protection are the tools to consider for sustainability to be achieved.
3) The Natural Value conception considers that nature has an intrinsic value that must be protected and respected. This notion implies that “*nature and its various component events and processes are part of a historical phenomenon and should be valued as such*” (Dobson 1998). Thus, this environmental interest in nature cannot only be secured by concerns about present and future generations of human beings that but, implies an obligation to protect nature. As such, nonetheless, Dobson (1998) argues that it not rules out the possibility that nature can contribute

[8] An additional factor of uncertainty is the limited existing knowledge about natural processes commanding species and ecosystems resilience, along with what would be the actual critical abundance, biological diversity and biodiversity levels.

to human welfare. This perspective, makes explicit however, that as "nature is a dynamic entity, natural elements are renewed through natural processes (e.g., old fish cohorts for new cohorts). This implies that substitution of nature for human-made equivalents is not acceptable, because nature should be allowed to take its own course" (Dobson 1998). In this context, protection is the only tool to achieve sustainability and present and future generations of non-human needs are highly important.

Swat and van der Windt (2005), following Dobdson (1998), analyze the above conceptions based on five questions: (1) what is to be sustained?, (2) Why is the object of question 1 to be sustained?, (3) How can the object of question 1 be sustained?, (4) How should be the objects of concern be prioritized? and, (5) Can human-made capital substitute or compensate for natural capital or nature?

Table 6 summarizes this analysis and shows that as people move towards more biocentric conceptions:

1) They have less confidence in the possibility of substituting natural capital by human-made capital,
2) They tend to equalize duties to nature (non-human needs) with duties to humans (human needs) and place them over human wants and,
3) They rely more on protection as the way to meet sustainability.

Table 6 Conceptions of environmental sustainability as per Dobson (1998).

Question	Critical Natural Capital	Irreversible Nature	Natural Value
1. What is to be sustained?	• Critical natural capital • Human welfare	• Irreversible nature • Human welfare	• Natural intrinsic value
2. Why is the object of question 1 to be sustained?	• Duties to future human generations	• Duties to nature • Duties to future human generations	• Duties to nature
3. How can the object of question 1 be sustained?	• Renewal • Substitution • Protection	• Substitution • protection	• Protection
4. How should be the objects of concern be prioritized?	**A > B > C > D > E > F**	**A > E > B > F > C > D**	**(A,E) > (B,F) > C > D**
5. Can human-made capital substitute or compensate for natural capital or nature?	• To a considerable extent but not always possible	• Not always possible	• Not possible in practice

Source: extracted from Swart and van der Windt (2005)
A: present generation human needs B: future generation human needs
C: present generation human wants D: future generation human wants
E: present generation non-human needs F: future generation non-human needs

3.1.2 Some precisions on concepts discussed

This sub-section and the following are an attempt to contribute to clarify some important aspects of the notions related to the goals of sustainability and sustainable development, that may have been "lost in translation" during the discussion from well intended actors with different disciplinary backgrounds and language and, it is by no means an attempt to "rediscover the wheel".

Thus, from the above discussion it is possible to identify a set of both, common and diverging elements among parties involved in the discussion and work towards the attainment of sustainability and sustainable development.

First, it is possible to identify at least three common approaches and principles leading to sustainability as follows:

1) It exist a moral obligation of presents generations towards the future, based on fairness and equity grounds.
2) Needs and well being/welfare[9] are important ingredients of the equation, whether they are centered on humans, on nature or on a combination of both.
3) There is a need to improve present human technologies and policies for development, with special emphasis on those economic-human activities directly using natural resources, the environment, the landscape and nature in general.

It is also possible to identify at least three diverging approaches and principles, as follows:

1) There is a need for present generations to carefully consider what resources they live behind, including "built-environment" for future generations to have the potential to be as well-off as present generations. This includes the notion of substitutability between natural resources and between natural and human-made capital, when they are deemed of at least equal value. It also includes the notion that specific species, landscapes and portions of unspoiled nature should be preserved if that is what present generations want. But, this should not be done under the name of sustainability.
2) Natural resources/capital and nature can hardly be substituted given their multifunctional and dynamic characteristics. Thus, there is a need to protect and preserve nature or natural capital in view of the unfeasibility to replicate their role, natural functions and role in providing critical components of the enabling natural environment for human well-being (human-made and natural capital are compliments).
3) There is a natural intrinsic value attached to nature natural processes (ecosystems) and species due to its multifunction and dynamic nature, as well as, non-human needs (i.e., nature's needs). This implies that nature is not only critical for human needs and well being, but that nature (i.e., species, landscapes and ecosystems) have needs of their own which can be

[9] As defined by Merriam Webster Dictionary: **Well – Being** is "*the state or condition of being well : a condition characterized by happiness, health, or prosperity : moral or physical welfare <the elders were responsible ... for the spiritual well-being of the people -- V.L.Parrington> <achieved a degree of economic well-being -- American Guide Series: New York*> and **Welfare** is "*the state of faring or doing well : thriving or successful progress in life : a state characterized especially by good fortune, happiness, well-being, or prosperity <we can use the knowledge ... for the future welfare of humanity -- H.S.Truman> <a generous mother who sincerely seeks her child's welfare -- H.M.Parshley> <increasing production has made welfare for all seem ... possible -- A.J.Toynbee> -- opposed to illfare*".

compared to human-needs. In fact, the Natural intrinsic value conception prioritizes present human and non-human needs to future human needs, let alone human wants (see Table 2).

The three common approaches and principles listed above form an appealing framework upon which to set a feasible approach to operationalize the concept of sustainability and sustainable development. Therefore, we will come back to them on the next section

The reading of the three diverging approaches and principles listed above clearly indicates that the third one may be very controversial as it weights human vìs-a-vìs non-human-needs. As it is clearly expressed in Table 2, this conception includes the idea that it is possible to prioritize non-human needs over human needs and human wants (present or future). In spite of whatever grounds this notion may be supported, it is sure it will be very difficult to defend it in the presence of present poor people or nations. Which are or will be denied not only the present possibility of an improvement in their own well being but, also, that of their descendants, if the opportunity of more and better employments cut short due to the need to protect resources and nature, based on values raised from non-human needs.

This is directly related to Solow's observation that the moral obligation to sustainability has also attached intra-generational distributional issues. This is to say, sustainability is not only related to the potential of the future generations to be as well of as we are, but it also says that present generations have not solved the well being of all their members. This is clearly an issue of equal options and enabling environments between those who have the capacities (at least financial and technical) and the rights of access to use resources (human-made and natural), to produce and exchange goods and services and those that do not. This is true both, within and between countries/societies/economies (rich versus poor).

Also related to this discussion of non-human need vìs-a-vìs human needs and wants are the second divergent and the third common principle/approaches. This, as in conjunction they establish not only, the need to protect nature and natural capital, not only for their characteristics but, also due to their crucial role in providing the enabling environment and necessary conditions for meeting human needs and improving their well being. The second divergent principle highlights not only the need to protect natural capital due to their multifunctional and dynamic characteristics but also, they being crucial in supporting human well being. The third common principle recognizes that present technologies and policies for resource use and development harm the environment and natural capital, thus unless corrections are made necessary conditions to meet human needs will be hindered in the present and future.

A further analysis of the two principles in conjunction contributes also to clarify that the principle of substitutability of natural capital for alternatives, of at least equal value (first divergent principle), needs to properly consider the multifunctional and dynamic characteristic of the components of natural capital and nature. That is, if properly valued the functional and dynamic characteristics, may show the unfeasibility to substitute them with alternatives that will not actually supply the same or equivalent services and processes. Thus, there is a need to properly value and consider the complementarities of natural capital and man-made capital. If this is done, the "at least equal value" principle will show the need to protect and preserve natural capital on grounds of their crucial role in sustaining the entire system and not only based non-human needs.

Therefore, the above discussion implies that the second divergent principle may be included as part of the basic framework to define our approach to operationalize sustainability and sustainable development. It also implies that divergent principles one and three have been dropped.

Before laying down the approach to operationalize the concept of sustainable development, it is necessary to provide some insights about the notion of "at least equal value" related to Solow's discussion of the need for present generations to provide options to future generations to be as well-of as present generations.

The expression used by Solow was "*…they need to provide a substitute of equal value (not necessarily a physical object, that is it could be knowledge)*" and, it is directly related to the economic notion of **dynamic economic efficiency**. Dynamic economic efficiency implies that for the rate of use of a resource to be efficient in time, the marginal value brought about by this use (for example the rate of extraction of a natural non-renewable or renewable resource) from one period to the next, needs to be equal in present value (discounted). In natural resource economics and environmental economics this marginal value is known as the "**marginal user cost**" and it is a measure of the resource scarcity (Hartwick and Olewiler 1997 and Tietemberg 2006).

For the moment, it is important to say that even though the term "scarcity" is usually related to quantity of the resource, in natural renewable resources analysis the term is directly related to the dynamics of the existing natural resources stocks, besides product and factor market conditions and others.

An important additional economic concept that needs to be presented is that of Total Economic Value-TEV has been extensively discussed in the economic literature (Boyle and Bishop 1985, Johanson 1991, Krutilla 1967, Reveret et al. 1986 and Turner xxx , among others). Here we will present only its central and salient features as they will be used to include in the adopted approach as a mean to properly account for all relevant values related to natural capital and nature.

The central idea behind the TEV is that natural resources and the environment provide many different values and many less or more complex categorizations have been presented over time. Nonetheless, at the heart of the TEV is the notion that nature provides use and non-use or existence values. Use values are typically divided between consumptive and non-consumptives uses (e.g., commercial fishing and forestry for consumptive and bird or wildlife watching for non-consumptive). In the beginning non-use or existence values were categorized as present or bequest values (e.g., the satisfaction that people may derive from simply knowing that certain species or habitats exist were related to present existence values and, bequest values were related to people's satisfaction that conservation of a certain species or habitat will retain the option that their children, grandchildren or future generations might directly or indirectly benefit its existence). As the discussion on sustainability and natural and environmental services evolved less anthropocentric values were identified, including the benefits derived to the entire system due to increasing knowledge on environmental services rendered by certain species and habitats (e.g., mangroves providing shelter and food for large number of marine species and protection to human communities from storm surges in tropical coastal areas and, forests values attached to their capacity to capture carbon dioxide, among many others). More recently the literature on economics and ecological economics concerned about environmental ecosystem services and conservation have been making efforts to value such attributes as habitat and ecosystems biological diversity (Fromm 2000 and Wattage and Mardle 2008).

As the discussion on sustainable development and sustainability evolved, traditional uses and values where increasingly being recognized as existences values attached to cultural, spiritual and religious motives (Berkes 198x and Reveret et al. 1986).

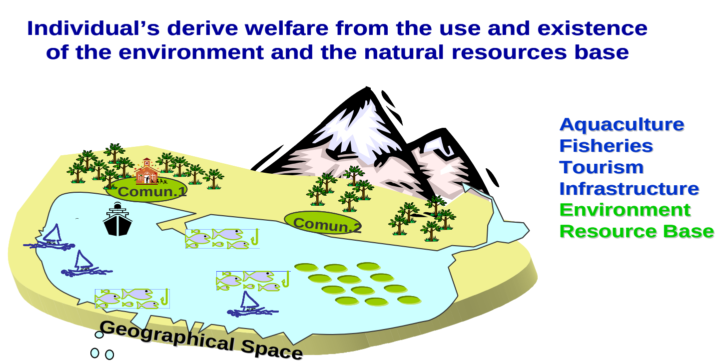
Many other details may be found in the economic literature, but the important thing to keep in mind, is that benefits and values attached to natural resources, the environment and nature in general, need to be divided into the different value components that may be attached to the benefits their use and existence provide, not only directly humans but also to those features and characteristics that are essential to maintain on time natures capacity to create a natural enabling environment without which present and future human will not be able to meet their needs and wants (well being).

3.1.3 An approach to operationalize the concepts

The approach adopted to operationalize the concept of sustainability will be understood and explained under the context of the paradigm of "Sustainable Development" of a geographical area at local, national or regional level. This approach is based on the notion that the goal of sustainable development is to maximize human welfare over time giving to consideration to environmental sustainability and social equity issues (distributional equity). The approach also considers that at the base of human welfare or well being is the notion Total Economic Value obtained from the use and existence of natural resources, ecosystems and environment conforming the geographical area where sustainable development needs to be attained.

To apply this paradigm it is necessary to identify the knowledge and information required to reach the sustainable development of human activities making use of the environment and the natural resources base such as aquaculture, fisheries and tourism, among others (Yáñez et al. 2005), through "disciplinary clusters" allowing the generation of such knowledge and information under a methodological framework of interdisciplinary, systemic, participatory, quantitative and dynamic nature. This will allow to study, understand and carry-on management of aquaculture, fisheries and other activities in a given geographical area. In this context, it is understood that aquaculture and fisheries are not conducted in isolation, but in direct relation to a geographical area and in interaction with the ecosystem and the natural resources base, either in competence or not, with a set of other human activities (Figure 39).

Figure 39 Geographical and spatial context in which aquaculture and fisheries take place

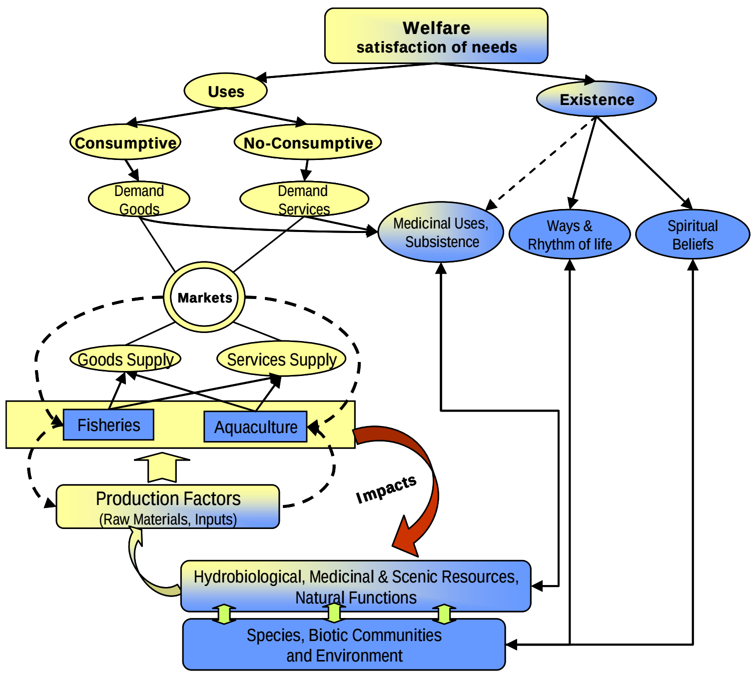


Source: Yáñez et al. 2005

In this geographical area, individuals derive welfare (expressed as net socio-economic benefits over time), from values related to alternative uses of the environment and the natural resources base, including preservation over time (existence values[10]).

Thus, aquaculture and fisheries may be represented as an articulated set of activities and interactions leading to the generation of these values and therefore, to certain levels of welfare. This representation is expressed in a conceptual model here named Aquaculture and Fisheries System (AFS), which is shown in Figure 40.

Figure 40 Schematics of the Aquaculture and Fisheries System (AFS).



Source: Yáñez et al. 2005

In this context, as shown in Figure 40, welfare is derived from alternative uses of the environment and the natural resources base, corresponding, on the one hand, to the exchange and enjoyment of these goods and services produced and exchanged in the market (demand and supply in the left hand side of Figure 40) and on the other hand, from the benefits derived from the existence of the resources and ecosystems (right hand side on Figure 40).

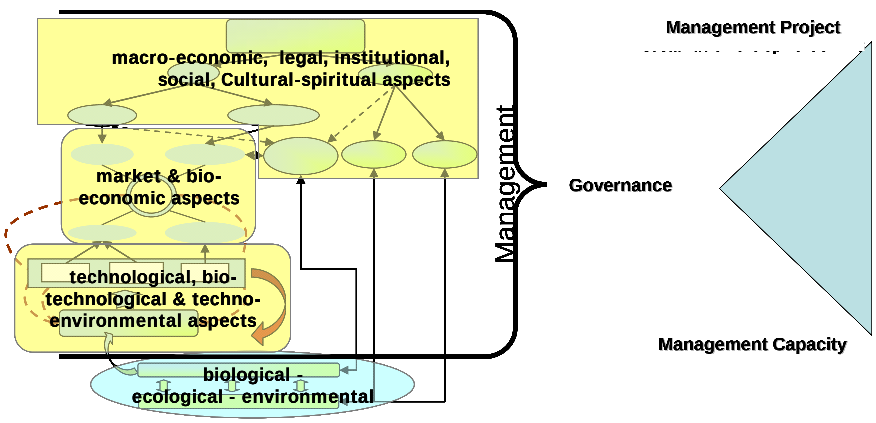
The production of goods and services (left hand side of Figure 40), besides capital, technology and human resources, requires the use of the environment and the natural resources base as a factor of production or as a source of raw material and inputs. This is the first relation of dependence, in which natural resources and the environment (aquatic) are extracted or used for the production of goods and services. In addition, due to inappropriate use strategies or to collateral effects of technologies used, the

[10] For details on existence value and other value concepts see Dixon et al. (1986), Reveret et al. (1990) and Gonzalez (1993), among others.

environment and the natural resources base becomes recipient of impacts, normally negative, that affect their natural productivity and resilience over time. The second source of welfare perceived by individuals comes from existence values related to the environment and the species comprising the natural resources base (right hand side in Figure 40). These values are normally not transacted in markets and refer to those arising from cultural-spiritual values individuals derive from their relationship with the species and the environment surrounding them. They also, are derived from the way in which fluctuations in nature (environment and species) affect and determine the rhythm and way of life. Other more concrete values, normally exchanged in primitive economies, arise from the medicinal attributes and uses of certain species.

The model proposed to understand the functioning of the AFS, may be expressed in terms of a cognitive system (Bennet and Chorley 1978) synthesized in at least five clusters of knowledge areas which are key to understand the functioning of the AFS and to construct a management system. This is shown in Figure 41. Seen in this way the AFS may be understood as a Socio-ecologic-Economic System.

Figure 41 Disciplinary clusters for the AFS, including management and governance



Source: Yáñez et al. 2005

In Figure 41 Management and Governance form the fifth cluster, transversal to the four previous clusters, and are the binding elements which will provide arrangements and instruments leading to sustainability of the system and of aquaculture at national-sectoral, regional and local levels. Central to the effectiveness of the previously mentioned arrangements is the level of awareness and political will between the public and private sector for the need of interaction and cooperation to attain sustainability.

In general, the work at national or sectoral level is conducted through a Process of Public Management, as it occurs in the Process of Governing (Matus 1997), which applied to the specific dominion of aquaculture and fisheries management, may be represented as a public Management Process, intertwining three distinct and mutually conditioned elements, named Management Capacity, Management Project and Governance, which constitute the vertex of the triangle (Figure 41).

The distinction includes three systems of different nature: a) one normative and proponent of a number of actions comprising the Management Project, b) a socio-political one, requiring positive science for the governance of the system (including private sector) and c) a directive and planning one, characterizing the governance capacity. The mutually conditioned nature of these elements signals a common thread, human action. Private sector awareness and recognition for environmental and social responsibility is also essential in this context.

The Management Project is a set of proposals for action to move towards the sustainable development of the system and in particular of aquaculture. The governance of the system refers to the possible actions required to generate techno-political feasibility for the passage towards sustainable development, both from the public and private sectors. In Management Capacity, referring to action capacity, the quality of the working systems and the structure of the organizational setting converge. Therefore, to improve the Management Capacity it is necessary to improve personal and institutional skills, their working systems specially those of high rank and their organizational setting.

The strategy to be developed, therefore, is a system that in the above mentioned triad (Figure 41), aims to improve the Management Capacity of the public and private sector.

3.1.4 Operationalizing the concept

Following the adopted approach, it is possible to define Sustainable Aquaculture as "***an aquaculture activity that contributes to provide the best possible level of welfare to society over time, through an optimal combination of use and conservation alternatives aimed to ensure present and future human well being and environmental sustainability***".

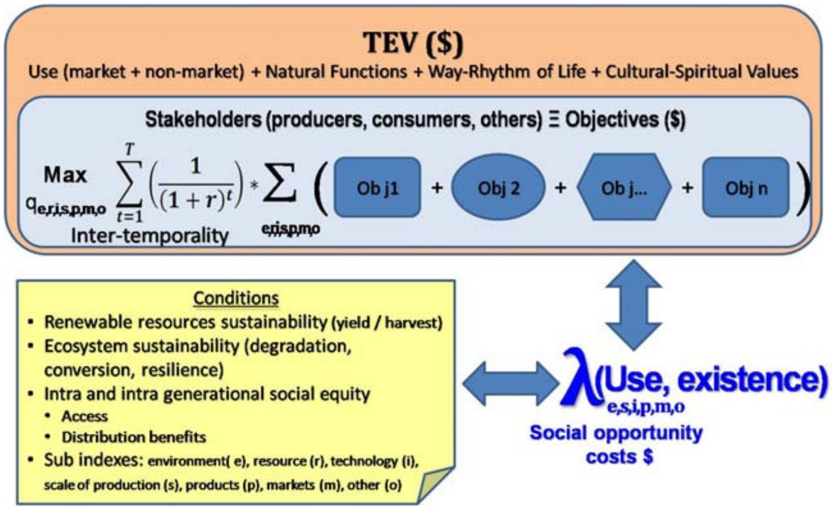
Thus the above implies that, to obtain a sustainable aquaculture it is necessary to reach a level of development for the aquaculture activity which will contribute to generate a maximum level of social welfare (seen as net socio economic benefits measured as total economic value-TEV) over time. In this context aquaculture development means the establishment and operation of certain a number of aquaculture production centers[11] in a number of alternative ecosystems and, considering a certain combination of culture species, technologies scales of productions, end-products and markets-consumers, that enables the generation of the maximum net socio economic benefits covering the spectrum of economic values included in TEV.

Figure 42 summarizes the above showing an objective function searching to maximize the present value of TEV, for a certain level of aquaculture production making use of a combination of environments (e), natural resources (r), technologies (i), scales of production (s), products (p), markets (m)and other uses (o), including preservation. The level of aquaculture development is shown by the level of the production $q_{e,r,i,s,p,m,o}$ and it is subject to a number of restrictions and/or conditions that look to ensure environmental and natural resources sustainability, social intra and inter generational equity.

The term λ refers to the opportunity cost to society of using and/ preserving the environment, the natural resource base, human made capital and human resources.

[11] The establishment of production centers necessarily implies the existence of all related economic activities from hatcheries and juvenile to grow out production centers and all the required ancillary industry (eg., feed, medicine, equipment and infrastructure, etc.).

Figure 42 Schematics of the achievement of sustainable development of aquaculture under the adopted approach



Source: elaborated by the authors

3.2 Review on sustainability indicators

Most of concepts, definitions and operational frameworks describes in this chapter are references from three main sources:

- ECASA project: Ecosystem Approach for Sustainable Aquaculture (http:/www.ecasatoolbox.org.uk).
- Quiroga, Rayén. 2007. Indicadores ambientales y de desarrollo sostenible: avances y perspectivas para América Latina y el Caribe. Serie Manuales 55. The Economic Commission for Latin America (ECLA).(CEPAL in Spanish)
- Workshop on Indicators for the sustainable development of the Chilean salmon industry. Organized by: Programa de Gestión y Economía Ambiental, Universidad de Chile, www.progea.cl

3.2.1 Origins, needs, concepts and definitions

The production of indicators is a fast developing activity in environmental and economic studies. The starting point began after the Rio conference in 1992, when awareness of worldwide environmental degradation became widespread. At the same time, the conditions needed to achieve sustainable development had to consider the complexity of the different systems involved, including ecosystems. To allow laymen to understand the idea, and the information related to the concept of sustainable development, it was proposed to build simple measurements of complex entities; these measurements were identified as Indicators.

The international action plan ‘Agenda 21’ urges that “indicators of sustainable development need to be developed to provide solid bases for decision-making at all levels” (UNCED, 1992, Chapter 40). The concept was almost as successful as the one of sustainable development, and the production of various indicators sharply increased in many different areas. Now the use of indicators is recognized as an efficient tool of communication for the wider audience, particularly in the field of sustainability

Various definitions were proposed for indicators, for different domains and audiences. The use of indicators within ECASA the definition should be narrowed to allow representation of scientific, social and economic data. Gallopin (1997) gives an operational definition of an indicator as "An operational representation of an attribute (quality, characteristics, property) of a system". An operational representation implies that indicators should be simple to understand and easy to communicate.

To be operationally useful, an indicator must be easy to measure and relate specifically to the system attribute. For example, when we measure the human temperature with a thermometer in the mouth, what is the system attribute? It is more than body core temperature, because humans, like other mammals, are homeotherms: the regulation of body temperature is an important part of the physical functioning of human beings, and a departure of more than 1 or 2 degrees from the normal body temperature is a good indicator of a dangerous state of health. Thus temperature is an indicator of system state.

In the ambit of ECLA (CEPAL in Spanish), an indicator is a variable that has been socially endowed with a meaning added to that arising from its own configuration scientific, to reflect a concern in summary form with respect to social development. An indicator provides an access ramp on a process or state of greater significance, or makes a perceptible trend or phenomenon that is not immediate or clearly detectable. An indicator is variable hypothetically linked to the variable studied that in itself cannot be directly observed (Quiroga, 2007).

3.2.2 Categories of indicators

In general terms the first basic classification could involve three major categories: environmental, economic and social indicators. However, there is practical experience based on a broad participatory process involving scientific, economic, socio and farmer opinions. ECASA has sought indicators of human Drivers, environmental Pressures, ecosystem States, Impacts on ecosystem goods and service, and human socio-economic Responses, as will be defined above. In addition ECASA has also examined more general categories of indicators, including those that show whether a site, water body or region may be sensitive to the potential effects of aquaculture and those that indicate whether an aquaculture site or industry is sustainable in socio-economic as well as environmental terms.

Aquaculture as other human activities is expected to affect the environment in various degrees although at the same time is strongly dependent on ecosystem quality and its resources. Thus, it appears vulnerable to environmental change and pollution caused by nature, other users of the coastal zone or by its own activities. Evidently, for the development of a sustainable aquaculture industry it is very important to know what forces affect most the water quality in aquaculture zones, and to what extent. That could, in turn, help in establishing appropriate indicators of the aquaculture-environment interactions which would further enable farmers, regulators and other groups of policy makers to effectively select sites for aquaculture activities and for monitoring the environmental impacts on aquaculture.

All studied activities are conceived as having a detectable effect on aquaculture; industrial activities, intensive agriculture, and even recreational activities may cause chemical pollution in the vicinity of aquaculture zones through their effluents; urbanization and tourism is more likely to cause bacteriological pollution; the biological aspect of pollution and disease transmission are connected with maritime activities and aquaculture itself. It is worth noting that though some human activities may occasionally have a catastrophic effect on aquaculture, e.g. oil spills caused by tanker accidents. The fact that these occur scarcely does not consider them more risky for the aquaculture industry and therefore their potential impact on aquaculture is rated lower.

3.2.3 Indicators and the ecosystem approach

Why use indicators in assessing the environmental impact of marine aquaculture? In the context of the ecosystem approach, Environmental Impact Assessment (EIA) studies are now conducted with a broader view. When assessing an activity for potential impacts, the spatial aspects, while of primary importance, should not be the only facet to be addressed. The activity may result in far-field damages. Also the damages may not only affect the different characteristics of the fauna and flora and the environment, it may interfere with the functioning and even the structure of the ecosystem within which the activity is conducted. Therefore to assess these intricate and often subtle changes requires the use complex measurements. These measurements may be translated into a simple concept by the use of indicators. As ECASA retains the primary objective of following an Ecosystem Approach, the indicators used are a reflection of the complexity of the ecosystems involved.

In Canada (Crocker, 2008), ecosystem indicators play a role in an ecosystem based management approach of human activities in aquatic ecosystems The pertinent question is always **"can we use this technique to measure an indicator of the interactions of aquaculture with the ecosystem?"**, and if yes, **"what are the thresholds where significant changes can be identified?".** With reference points, thresholds and limits, they form part of a system for monitoring management and performance against operational objectives in an adaptive and risk based management cycle. Indicators may not be used directly for reporting or decision making, but may instead used to improve understanding of the dynamics of the system and interpret trends i.e. many environmental indicators which serve as proxies. Every indicator has a question such as:

– How is the extent and distribution of aquatic habitats changing over time?

– How is the ecological condition of aquatic habitats changing over time?

– What are the causes of coastal habitat change?

– Current state of the ecosystem?

3.2.4 Socio-economic indicators of sustainability

Sustainability indicators are part of the governance framework for aquaculture, and most commentators now accept that the socio-economic as well as the environmental dimensions of sustainability should be included. These indicators need to measure not only the operating performance of commercial fish farms – which at its simplest could be summarized using financial ratios - but the wider impacts of aquaculture on society at large. Indeed, it is precisely these impacts which, within the DPSIR framework, can expected to invoke an institutional response intended to alter the way in which aquaculture is regulated and managed.

The socio-economic indicators proposed in the ECASA Project are classified in terms of four major governance objectives – supply availability, livelihood security, economic efficiency and social acceptability. It is important to emphasize that, like all indicators, they are often only meaningful when used comparatively. The basis of comparison may typically be either (i) normative – i.e. the performance of aquaculture is compared with some standard or norm considered acceptable (e.g. income per capita, environmental damage costs), or (ii) empirical – i.e. the industry's performance is tracked over time or compared with that of another country (e.g. trends in employment, productivity, prices, etc.).

3.2.5 Indicators and models

ECASA consider that indicators and models are two kinds of tools, but their objectives are quite different. Indicators measure the actual status of the environment before, during or after an event such as the start of the aquaculture growing cycle. However, the relationship between the event and the indicator requires scrutiny which is one of the reasons why several indicators should be used to describe the impact of aquaculture on the marine environment. Indicators cannot predict any future environmental conditions, as models do. In the context of an EIA, indicators serve as a reference status or as a signal for environmental change (qualitative or quantitative) and form the basis of a monitoring program.

Models however, can predict future conditions without any further measurements since they have been validated and field tested before use. Models are increasingly more flexible and precise, mainly due to increasing computer power, but their quality depends on the models underlying processes and validation of results through a large range of environmental conditions.

Using both indicators and models greatly increases the ability of scientists, regulators, producers and environmental consultants to carefully assess the potential impact of new aquaculture operations, to characterize and evaluate any actual impact, and to define areas where the impact of marine aquaculture could minimized.

3.2.6 Indicator use: thresholds and values

To be fully operational, it is advisable that an indicator comes with a simple rule to interpret its significance to an environmental impact. Two different possibilities are proposed, when sufficient knowledge or experience exists on the meaning and the significance of the indicator.

The easier solution is to compare the indicators result with a threshold, known to correspond to a limit between satisfactory conditions, and unsatisfactory or unacceptable conditions. Some difficulties may arise if the indicator was not tested in adequate conditions and appropriate environment. To ensure the indicators considered in ECASA have been properly tested an extensive field campaign was conducted to field test all the indicators in actual conditions of currently operating production sites of European marine aquaculture.

3.2.7 Summary

Indicators represent a good tool for the interpretation of trends and environmental impacts in the ecosystem where aquaculture is developed. To apply them it is necessary to define a given set of objectives and conditions (i.e., models) based on the best scientific knowledge of environmental, economic and social variables, the real experience from farming activities, an adequate budget for its monitoring, control and surveillance and, most importantly, a set of social choices clearly stated and carefully defined (development and management objectives and goals).

3.3 Possible indicators for sustainable aquaculture

3.3.1 ECASA methodology for the selection of indicators

The following methodology was select and test indicators of the impacts and interactions of aquaculture with the marine environment:

a. The 16 ECASA partners have experience in many types of European marine aquaculture from the culture of fish in cages in various environments (e.g. sheltered fjords to the open sea), to the culture of mollusks in longline systems in intertidal areas for different species (e.g. oysters mussels, clams). Based on partner scientific research, a list of potential indicators was collated.

b. Indicators were proposed using an indicator template sheet, collating all the necessary information so that an indicators appropriateness and scientific validity could be assessed for different environments.

c. An initial selection of indicators was then made, based on scientific validity and appropriateness. This selection was then split into sub-groups (sediment, benthic, water quality, coastal zone management, genetics and socio-economic). The wide ranging experience provided by the different partners allowed the list to be narrowed down to the most appropriate indicators relating to marine aquaculture.

d. The short list of indicators was then tested in the field at sites representing the major European aquaculture types. According to the type of aquaculture and the specialty of each partner, these indicators were tested in conditions of true aquaculture operations, and compared each time with reference sites where the environmental conditions were of a similar nature (e.g. such as depth, sea bed type).

e. The results of these field tests are being presented to European stakeholders in September 2007 at a special workshop as they are the final users of the indicators. Comments and criticisms arising from this workshop will be considered and a final list of indicators will be recommended by ECASA in this Toolbox.

During the selection process different indicator frameworks were used to assess the indicators. The most developed is the **DPSIR** framework, which allows the classification of indicators according to their use, and the **Driving** forces, the environmental **Pressure**, the **State** of the environment, the **Impact** on the environment, and the **Response** from the environment.

Another framework can be considered as specific to the ECASA community: it corresponds to the different sub-groups dealing with the different indicators, as seen above. Finally, it is interesting to consider another framework based on a short typology of the European marine aquaculture, as specific productions may need a specific set of indicators. To demonstrate this, the impact of mollusks on the water quality is quite different from that of fin-fish aquaculture.

3.3.1.1 Benthic fauna indicators

The ECASA study sites extended both over the Mediterranean and the Atlantic and covered an ample gradient of latitudinal locations, water depths, and different target species. Moreover, the complementary sediment analyses made in these locations differ from each other. Only few variables are similar across all sites e.g. Total Organic Matter (TOM) or redox potential. These factors make comparison among sites and variables very difficult to undertake on a global basis. However, the availability of a data set of species composition and density of a broad set of locations makes it possible to check some of the benthic indicators proposed within this project.

The biological data sets, containing the density and species composition, per replicate and station, were homogenized and the structural parameters (density, biomass, etc.) were calculated on the basis of square meter. Then, other univariate variables were derived (Shannon's diversity, AMBI, etc.) and comparisons were made between sites.

The list of ECASA benthic fauna indicators

Indicator name	DPSIR class	ECASA code
AMBI	Impact	AMBI
Benthic trophic group	Impact	BTG
Biomass fractionation index	Impact	BFI
ITI	Impact	ITI
Macrofauna presence	Impact	PRESENCE
Meiofauna sediment test	Response	MEIOSED
Meiofaunal diversity	Impact	MEIODIV
Multivariate indexes	Impact	MULTIVAR
Univariate indexes	Impact	UNIVAR

The most important problem when analyzing the data is the absence of the same variables at all locations. However, when studying those variables which are common to all datasets, several conclusions can be obtained:

- Some locations do not show clear gradients of impact, in terms of the benthic indicators selected in ECASA. In these cases it seems that the good dispersion of the discharges from the cages avoids any damage to the benthic communities. This good dispersion seems to be related with: (i) the situation of the cages on high water depths (>40-50 m), such as in Spain or Norway; (ii) the strong dynamics of the area e.g. currents, such as in Spain and ICRAM.
- The gradients of impact are related with the distance to the cage and depth, being the most impacted area that extending until 25-50 m from the cages.
- Most structural parameters are correlated between them.
- AMBI seems to be a good indicator of the benthic stress, related with organic matter percentages. This is also related with redox potential (showing the oxygen consumption under the cages).
- Multiple regression using AMBI as dependent variable and distance to the cage, depth, and TOM as independent, explains 53.6% of the total variability

Water quality indicators i.e. chlorophyll content, nutrient concentration, oxygen concentration, transparency of the water column (Secchi depth), and the concentration of particulate organic matter, POC, can be used to evaluate the effect of aquaculture on the surrounding environment. The values of these indicators can be found by in-situ observations. Other indicators can be used to evaluate how the water quality of the surrounding water influences the actual farm. Examples of such indicators are holding capacity expressed as maximum production with respect to oxygen and ammonium conditions in the farm, and fish growth. These indicators are calculated, and do not only depend on one parameter e.g. oxygen or ammonium concentrations of the surrounding water but also on the flushing time, temperature, fish species, etc.

3.3.1.2 Sediment indicators

Indicator name	DPSIR class	ECASA sub-group	ECASA code
Ammonia in pore waters	Impact	Sediment	AMMPW
Carbon quality (Rp index)	Impact	Sediment	Rp
Heavy metals	Impact	Sediment	HEAVYMET
MUFAB	Response	Sediment	MUFAB
Nitrifier bacteria	Response	Sediment	NITBACT
Oxygen consumption fluxes	Response	Sediment	O2FLUX
Phosphate in pore waters	Impact	Sediment	PHOSPW
Redox Eh	Impact	Sediment	REDOXEh
Sediment flux (traps)	Impact	Sediment	SEDFLUX
Sulfate and ammonia gradients	Response	Sediment	SULAMMGRAD
Sulphide/oxygen probe	Response	Sediment	SULPROBE
Total Nitrogen (surface)	Impact	Sediment	TNSURF
Total Organic Carbon	Impact	Sediment	TOC
Total Organic Carbon (surface)	Impact	Sediment	TOCSURF
Total Phosphorous (surface)	Impact	Sediment	TPSURF

The assessment document elucidates among other things the fact that most of the indicators mentioned above describe the instantaneous condition and do therefore show large variations over time. Long (years) and rather frequent measurements are needed to find trends or changes in the environment. The objective of the document was to assess the different water quality indicators suggested during ECASA based on some important evaluation criteria, i.e. obvious significance, clarity in design, realistic collection or development costs, availability of data, high quality and reliability, theoretical basis, appropriate spatial and temporal scale.

3.3.1.3 Water quality indicators

Indicator name	DPSIR class	ECASA code
Chlorophyll a	Impact	CHLa
Maximum production while maintaining high water quality in farm	Impact	MAXPRODWQ
Minimum O_2 in bottom waters	Impact	MINO2BOT
Particulate OC in sea water	Impact	POCWC
Secchi depth	Impact	SECCHI
Winter nutrients	Impact	WINTERNUT

3.3.2 Socio-economic indicators of sustainability

Sustainability indicators are part of the governance framework for aquaculture, and most commentators now accept that the socio-economic as well as the environmental dimensions of sustainability should be included. These indicators need to measure not only the operating performance of commercial fish farms – which at its simplest could be summarized using financial ratios - but the wider impacts of aquaculture on society at large. Indeed, it is precisely these impacts which, within the DPSIR framework, can expected to invoke an institutional response intended to alter the way in which aquaculture is regulated and managed.

The socio-economic indicators proposed here are summarized below, classified in terms of four major governance objectives – supply availability, livelihood security, economic efficiency and social acceptability. It is important to emphasize that, like all indicators, they are often only meaningful when used comparatively. The basis of comparison may typically be either (i) *normative* – i.e. the performance of aquaculture is compared with some standard or norm considered acceptable (e.g. income per capita, environmental damage costs), or (ii) *empirical* – i.e. the industry's performance is tracked over time or compared with that of another country (e.g. trends in employment, productivity, prices, etc.).

3.3.2.1 Socioeconomic indicators

Indicator name	DPSIR class		ECASA code
Attitudes	Impact	Social acceptability	PUBATT
Conflicts	Impact	Social acceptability	CONFLICT
Consumer prices	Impact	Supply availability	CONPRICE
Consumption products	Impact	Supply availability	CONPRODCAP
Consumption share	Impact	Supply availability	CONPRODTOTFISH
Damage costs	Impact	Economic efficiency	DAMAGE
Employment	Impact	Livelihood security	TOTEMP
Income	Impact	Livelihood security	INCCAPITA
Multiplier indicators of dependency	Impact	Livelihood security	MULT
Output	Impact	Supply availability	OUTPUT
Producer prices	Impact	Economic efficiency	PRODPRICE
Productivity ratios	Impact	Economic efficiency	PRODRATIO
Profit	Impact	Economic efficiency	PROFIT
Protection costs	Impact	Economic efficiency	PROTECT
Regional dependency ratios	Impact	Livelihood security	RDR

3.3.3 Coastal Zone Management indicators

Indicator name	DPSIR class	ECASA code
Aquashoreline	State	SHOREPROD
ASSETS	Pressure, State, Response	ASSETS
Validated distance	State	VALIDDIST
Water availability	State	WATERAVAIL

3.3.4 Other experiences to be considered

In Chile, there is in progress a project on the selection of sustainable development indicators for salmon industry, lead by Dr. Raul O'Ryan from Universidad de Chile. They have presently defined a methodology which included definitions of Long, Medium and Short lists of indicators identified through a number several participatory tools, including both public and technical seminars and workshops. This project is defining environmental, economic and social indicators.

According to O´Ryan et al. (2008), the criteria used to define short list of indicators were oriented to:

Reliability of Data: scientific validity, ease of measurement, availability, quality, cost-efficiency of production, time series, accessibility.

Regarding monitoring and evaluation: representativeness, desirability scale, geographic coverage, sensitivity to change, specificity, connection

Utility to the user: applicability, no redundancy, understandability and interpretability, reference values, retrospective-predictive, comparability, opportunity

For each ambit (environment, economic and social) there are a number of indicators.

Environmental ambit / selected indicator

- Environmental assessment
  - Monitoring, control and surveillance / Citaciones por incumplimiento de normas ambientales
  - Research / Scientific papers related with sustainability in the Chilean aquaculture.
  - Territorial / National production of salmon in lakes.
- Energy: Feeding, resource demand and conversion factors / Produced wastes during feeding
- Chemical uses / type and quantity of used antibiotic
- Water uses
- Biotechnological management
- Production / cultivation density
- Sanitary state
- Biodiversity / Fish escapees

- Water quality
- Greenhouse effect
- Wastes
- Sediment condition / Farms with anaerobic conditions

Economic ambit:

- Income Distribution
- Contribution to GDP
- Investment and Spending
- productive linkages
- Change of productive activities
- Revenue from leases / Taxes
- Employment
- Unemployment
- Contribute to the development of SMEs
- Labor productivity
- Training

Social Ambit

- New dynamic urban sector
- Health
- Education
- Abandonment of traditional socio-cultural practices.
- Appearance / increase in social problems
- Poverty
- Indirect infrastructure Development / Areas
- Green
- Housing
- Scientific-Technical

3.3.5 Summary

There is good experience in methodological approaches towards the identification and selection of different ambits associated to aquaculture. The previous hard work has been done (long, medium and short list) and from this platform it is possible to explore options for a particular scenario (an Economy) and assess which indicator is possible to apply in its aquaculture management.

3.4 Sustainable aquaculture: definition

During the First or Preparatory Workshop of the project, held in Puerto Montt, Chile on October 1 and 2, 2008 the concepts, objectives, conditions and indicators of sustainability, sustainable development and sustainable fisheries development were presented and discussed in order to obtain an operational definition of "Sustainable Aquaculture" and to set the basis to define the APEC strategy on sustainable aquaculture.

In addition to the definition of sustainable aquaculture presented in Section 3.14 above, a number of definitions were reviewed by workshop participants as follows:

a) **FAO definition of aquaculture**: The farming of aquatic organisms including fish, mollusks, crustaceans and aquatic plants. Farming implies some sort of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated, the planning, development and operation of aquaculture systems, sites, facilities and practices, and the production and transport. (Modified from TGRA-5 p.6) From "definitions" section, draft "Technical Guidelines on Aquaculture Certification"—version prepared for SC-AQ 4, Puerto Varas.

b) **FAO definition of sustainable aquaculture**: The management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment of continued satisfaction of human needs for present and future generations. Such sustainable development conserves (land,) water, plants and (animal) genetic resources, is environmentally non-degrading, technologically appropriate, economically viable and socially acceptable" (FAO Council, 1988).

c) **Australian Government Council definition of Sustainable Aquaculture (ESD 1992)**: "Using, conserving, and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased".

d) FAO definition of sustainable development of fisheries: To place fisheries in a sustainable development context, policies must specifically address the trade-offs between the present and the future relating to the depletion of fish stocks as well as the disruptive impacts of fishing activity (or other economic activities), coastal settlements and waste disposal on the wider marine ecosystems.

   Objectives to consider:

   a. Sustaining fisheries harvesting and processing activities based on specified and identifiable marine ecosystems;
   b. Ensuring the long-term viability of the resource which supports these activities;
   c. Catering for the well-being of a fishery workforce within a wider community and broader economic context; and
   d. Maintaining the health and integrity of marine ecosystems for the benefit of other uses and users including biodiversity, scientific interest, intrinsic value, trophic structure and other economic uses such as tourism and recreation.

e. Indicators are now needed that can be used to determine how well these objectives are being pursued and whether the broader goals of sustainable development are being achieved

After consideration of all definitions presented and in-depth discussion of the approach adopted and concepts behind it, the following operational definition was adopted by the participants to the Preparatory Workshop and the project team. This definition reads "**A sustainable aquaculture is an activity that provides the best possible level of benefits to society, through the optimal use of resources to ensure present and future human well being. Such an activity should be environmentally responsible, socially equitable and economically viable.**"

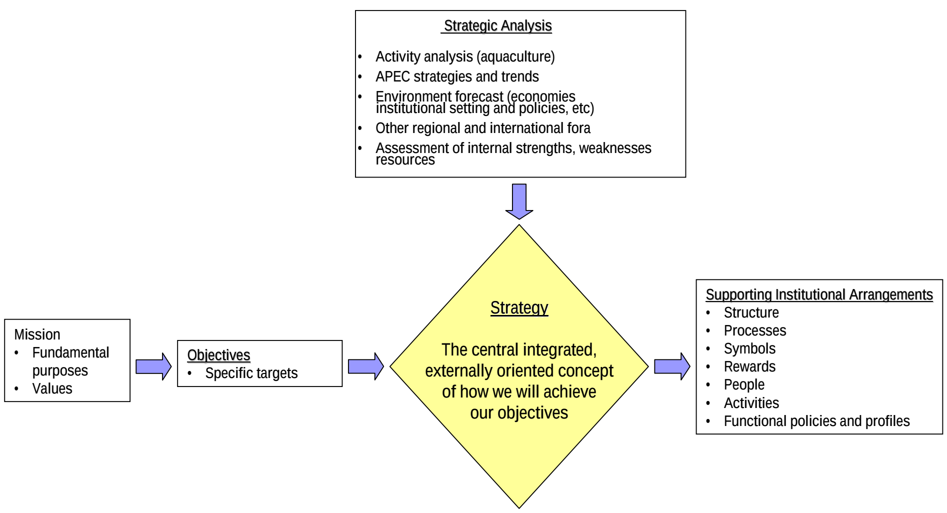
4 CONCEPTS AND APPROACHES FOR A SOUND STRATEGY ON SUSTAINABLE AQUACULTURE FOR APEC

4.1 Strategies: concepts, approaches and variables to consider for sustainable aquaculture

The perspective followed to set the basis for the process on designing the strategy for sustainable aquaculture is based upon Hambrick and Fredrickson (2001) approach to what it is a ***strategy*** and how it is designed. According to these authors, the word strategy is derived from the Greek "***strategos***" which means "the art of the general" and thus it is important to think about what is special about the work of a general. The general is responsible for multiple units on multiple fronts and multiple battles over time. Thus, the challenges of a general and the value-added of the generalship is in orchestration and comprehensiveness. Great generals think about the whole. They have a strategy that has pieces or elements, but they form a coherent whole. In this context, therefore, ***strategy*** it is understood as **"a central integrated, externally oriented concept of how to achieve one or more objectives"** (Hambrick and Fredrickson 2001).

As depicted in Figure 43 a strategy is designed bearing in mind the mission and objectives to be attained and based upon a strategic analysis of external and internal factors related to who will implement the strategy (strengths, weaknesses, resources, opportunities and threats).

Figure 43 the process of design a strategy

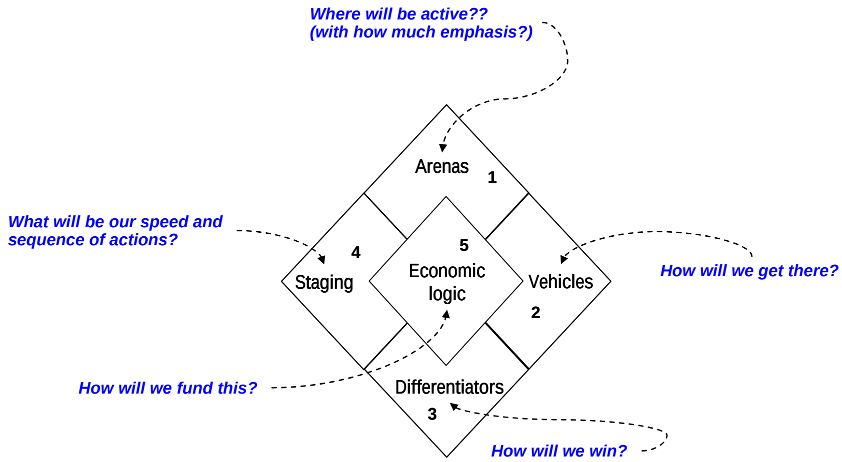


Source: Hambrick and Fredrickson (2001)

Figure 43 also indicates that the final step in the process of designing the strategy is the specification of the Supporting Organizational Arrangements, which includes the definition of structures, processes, symbols, rewards, people involved, activities to be conducted, functional policies and profiles.

Hambrick and Fredrickson (2001) indicate that to design a strategy it is necessary to define ***five major elements or components*** which are listed as: (i) Arenas, (ii) Vehicles, (iii) Differentiators, (iv) Staging and (v) Economic logic (Figure 44).

Figure 44 Major elements or components of the strategy to be designed



Source: adapted from Hambrick and Fredrickson (2001)

Arenas

The Arenas refer to dominion and the emphasis of the actions to be considered in relation to the pursued objectives (i.e., where will be active and with how much emphasis. Some examples for this project are: what type of aquaculture products would we be considering high value for export markets, high value for national markets, low value for local markets, subsistence aquaculture. Would we be considering the entire APEC region or only tropical ecosystems? Would we be considering cage aquaculture, pond aquaculture, long-lines, etc.

Vehicles

Vehicles refer to how we will be reaching our objectives (e.g., through mandatory or voluntary multilateral agreements, through mutual recognition or equivalency of standards, collaborative mechanisms, etc.).

Differentiators

Differentiators refer to how we will ensure the attainment of the objective of sustainable aquaculture (e.g., traceability systems, aquaculture certification, etc.)

Staging

Staging refers to what will be the speed and sequence of actions to be taken to achieve our objectives (e.g., all economies will adopt traceability systems and comply with aquaculture certification standards at the same time, or there will be some economies that will adopt them earlier and others later, etc.)

Economic logic

The economic logic refers for example to what will be the financial mechanisms that will best suit the actions to be taken to achieve sustainable aquaculture in the region.

4.2 Basis for a strategy on sustainable aquaculture in APEC

Bearing in mind the adopted approaches, both on sustainable development and strategy design, and the concordant operational definition of sustainable aquaculture specified in section 3.4, the following steps are necessary to define the final strategy: (i) to lay down the general conditions for the existence of aquaculture development, (ii) to lay down the conditions for sustainable aquaculture to be reached, (iii) to conduct a SWOT analysis in order to identify gaps between present general conditions of aquaculture in APEC and general conditions previously identified for sustainable aquaculture and (iv) to identify ways to bridge these gaps and specify measures to implement them.

4.2.1 General conditions for aquaculture development

In synthesis, general conditions for aquaculture development may be summarized in the following general functional relationship.

$$\text{Aquaculture Development} = f(\text{Natural Enabling Environment; Social Enabling Environment; Markets-Human Needs; Capital–Labor-Entrepreneurship; Government Objectives})$$

Where:

a) ***Natural Enabling Environment (NEE)***: refers to the environment and the natural resources base required to develop aquaculture as a human activity (from subsistence to large-scale-international enterprises). As such it is understood that the NEE is necessary in three ways:

   a. As the physical environment (water, land, oxygen, temperature, etc.) required to conduct aquaculture,
   b. As the source of the individuals to be cultured and finally marketed/consumed
   c. As the source of raw material for the feed required to conduct aquaculture and raise individuals to expected sizes and weights.

   The level and intensity in which the NEE is required will mainly depend on the species to be cultured, the technologies used, the scales of production and level of demand, among other things.

b) ***Social Enabling Environment (SEE)***: refers to the "social system" (I do not have a better term for the moment) required to develop aquaculture as a human activity (from subsistence to large-scale-international enterprises). As such it is understood that the SEE is necessary in various ways as follows:

   a. The Institutional setting (private, public, social, political) and legal framework under which operate human activities (economic or not). Some elements that need to be analyzed are:
      i. The institutional/organizational cultures (way of doing things)
      ii. The institutional/organizational structures (scope, dominion, role, etc.)
      iii. Existing laws and regulations promoting and/or constraining aquaculture
      iv. International/regional agreements or arrangements signed/adopted
   b. Existing infrastructure (transport, communications, sanitation, electricity-energy, etc.)
   c. Existing financial system (public, private) and access mechanisms

d. Existing educational and research system (basic, technical, scientific), relating to available human capacities and technologies
e. Existing set of policies, strategies, action plans and protocols
f. Cultural setting (favorable or unfavorable to technologies, species, etc.)
g. Political will for social improvement/betterment and equity (inter and intra generational)

c) ***Markets-Human Needs (M-HN):*** aquaculture has been developed in at least three ways:

a. A complementary activity to provide additional food for self subsistence (traditional ways)
b. As an economic, commercial, highly profitable activity, with many aspects f its development being commanded by demand-market behavior and private entrepreneurship moved by the goal of own wealth creation
c. As an alternative complementary economic, commercial activity oriented to supplement incomes, usually originated by national programs seeking economic development of a region or country.

It is important to clarify that human needs/wants are usually expressed through market demand but, for this to be true people demanding goods need to have a effective purchasing power. This is not true in most developing countries or economies, were vast numbers of poor people cannot express their needs through demand in markets. That is why we have attached the terms "Market-Human Needs".

d) ***Capital, Labor and Entrepreneurship (K-L-E)***: refers to the fact that to develop a human activity, specially these like aquaculture oriented to produce food, after human needs/wants for this type of food are expressed (through market or other means) there is a need to have someone(s) with the will and capacities to develop the activity generating the product/good that will satisfy the expressed need or want. This is summarized as the need to have Capital (investment and working capital), Labor (work force expressed in working hours available of different training and levels of capacities) and the capacities required to develop the activity from the technical, scientific, managerial and political aspects, among others, summarized as entrepreneurship.

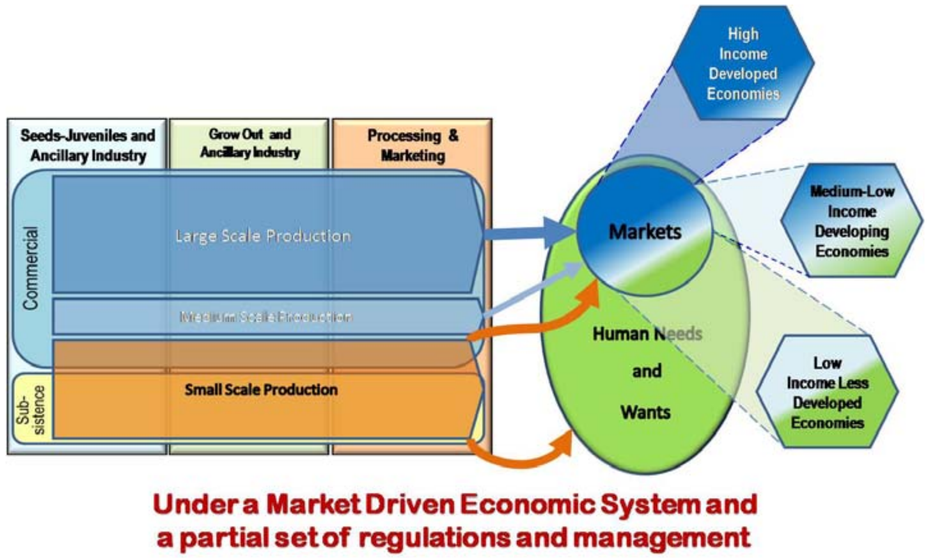
e) ***Government Objectives (GO)***: This refers to the fact that aquaculture and all human activities are conducted by people pertaining to a certain country or economy which has a Government, which in turn has stated (or unstated) objectives and goals. If, the human activity to be developed (eg. Aquaculture) generates direct or indirect products or effects favorable or concordant with their objectives and goals, then the activity to be developed will face a positive SEE or ways to improve it will be devised. Otherwise, development of this activity will be difficult.

Bearing in mind the above specified general conditions for aquaculture development it is possible to synthesize the process of aquaculture development under Market Driven Economic Systems and the normal existence of a partial set of regulations. This process is depicted in Figure 45.

As it may be observed in figure 45, under these conditions aquaculture development tends to be directed to high value species mostly oriented to markets in High Income Developed Economies and produced using large-scale-high-technology production systems. Markets in Medium-Low Income Developing

Economies are also part of the equation. Small-scale production-low-technology production systems also exist but mainly related to subsistence activity.

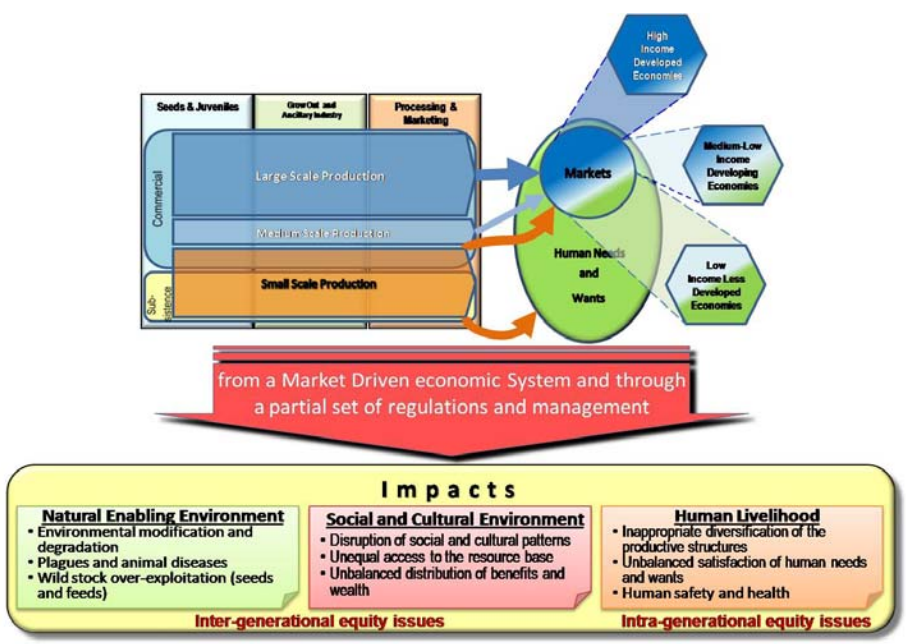
Figure 45 Schematics of the aquaculture development process under a market driven economic systems and the existence of partial set of regulations



Source: elaborated by the authors

At least three types of impacts arise from this type of development and they are summarized in Figure 46.

Figure 46 Schematics of impacts generated by the aquaculture development process under market driven economic systems and the existence of a partial set of regulations

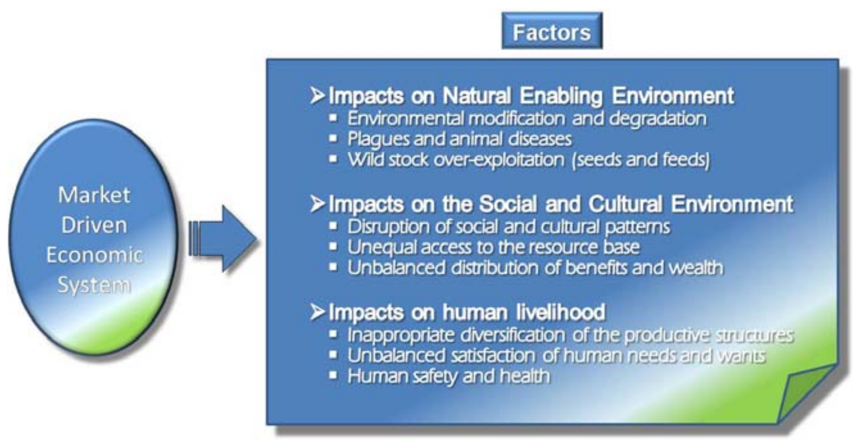


Source: elaborated by the authors

As it may be observed in Figure 46, the aquaculture development process generates impacts on the NEE in special with reference to: (i) Environmental modification and degradation; (ii) Plagues and animal diseases and (iii) Wild stock over-exploitation (seeds and feeds). Impacts on the Social and cultural environment are also identified and these may be listed as: (i) Disruption of social and cultural patterns; (ii) Unequal access to the resource base and (iii) Unbalanced distribution of benefits and wealth. Finally, it is also possible to identify impacts on Human Livelihood as: (i) Inappropriate diversification of the productive structures; (ii) Unbalanced satisfaction of human needs and wants and (iii) Human safety and health.

Thus, from the above it is possible to summarize a set of factors preventing the attainment of sustainable aquaculture and they are summarized in Figure 47.

Figure 47 Factors preventing the attainment of sustainable aquaculture, under market driven economic systems and the existence of a partial set of regulations.



4.2.2 General conditions for sustainable aquaculture

From sections 4.2.1 and above, it is clear that the two main factors preventing the attainment of sustainable aquaculture are: (i) the fact that the development process takes place under the context of a market driven economic system and (ii) the existence of a partial set of regulations.

With respect to the market driven economic system there is clear evidence that even though markets are essential components of economic activities and development, markets, by themselves they are far from perfect resource allocators (i.e., market failures due to externalities and imperfect property and use rights). Thus, market imperfections prevent the efficient allocation of natural and human made capital over time (i.e., use and preservation of the environment and the natural resource base, through the use of physical-man-made capital and technologies). On the other hand, most economies relying on market drive economic systems, expect markets to good resource allocators and have over time implemented a patched and partial set of regulations usually aimed to prevent impacts with respect to the NEE. Very few economies have set regulations or initiatives to prevent and correct the effects of impacts on the Social and Cultural Environment and on Human livelihood.

Therefore, in order to set the basis for a strategy effectively contributing to the attainment of sustainable aquaculture a system or coordinated and articulate measures to prevent, mitigate and or control the above mentioned impacts and factors is necessary. For this, the project team has coined the term

"Socially Driven Economic System" which implies to consider the development of aquaculture in a context promoting the idea of sustainable aquaculture contributing to maximize human welfare and wellbeing over time. This, does not implies that markets are not considered to constitute a crucial part of the system but, to recognize and strengthen the need to build mechanisms to prevent, mitigate and/or control aquaculture development impacts on NEE, Social and Cultural Environment and Human Livelihood, as well as, to set objectives and goals aimed at an aquaculture activity that provides the best possible level of benefits to society, through the optimal use of resources to ensure present and future human well being. Such an activity should be environmentally responsible, socially equitable and economically viable. Figure 48 depicts the idea for the need of a socially driven economic system, as a context under which to design a system of interventions, tools-mechanisms and indicators that will allow to reach sustainable aquaculture.

Figure 48 Schematics of a Socially Driven Economic System, as the basis to design and implement a set of interventions, tools-mechanisms and indicators for sustainable aquaculture

Source: elaborated by the authors

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