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Ecuador Case Study: Climate Change Impact on Fisheries

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ECUADOR CASE STUDY: CLIMATE CHANGE IMPACT ON FISHERIES

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1. Background/ Introduction

1.1. Current Socioeconomic Setting (last 10 years)

During the last ten years (1997-2007) the socioeconomic conditions in Ecuador have been strongly marked by several factors, mainly:

1. Political instability: none of the elected presidents have finished their periods since 1996. There was a coup in 1997 (F. Alarcón, interim president); then elections in 1998 (J. Mahuad elected) follow by a coup in 2000 (G. Noboa, the vice-president took charge); elections again in 2002 (L. Gutierrez elected) follow by a coup in 2005 (A. Palacio, the vice-president took charge), and elections again in 2006 (R. Correa elected).
2. After the bank assets were frozen in March 1999, the dollar became the national currency (instead of "sucre") and the salary scale suffered in the conversion. Unemployment went high and the exodus of more than a million Ecuadorians to Europe (mainly Spain and Italy) and USA started. Currently, remittance from the immigrants account for the second income of the country after petroleum, and in 2003 there were in the amount of 1,656 millions of dollars.
3. The extraordinary 1997-1998 ENSO event resulted in damages of 2,881.60 million dollars (CAF, 2000), mainly to highway infrastructure ($ 785.1 millions dollars) and agriculture sector ($1,186.8 millions dollars) (see table 1.1). The area of ENSO influences is found below 1000m heights, which comprises the coastal plains.
4. The 1999-2000 La Niña event followed the ENSO extraordinary 1997-1998 ENSO, along with an epidemic (White Spot Virus Syndrome) that almost whipped out the Ecuadorian Shrimp industry, which at that moment employed 8% of the economically active population of Ecuador.

Table 1.1 Ecuador total damages during the 1997-98 ENSO event in millions of dollars. Adapted from CAF (2000).

Sector, subsector and item	Total damage	Direct Damages	Indirect Damages	Effects over the payment balance (exports/imports)
Total	**2,881.60**	**845.50**	**2,036.00**	**658.40**
Social sectors				
Housing	152.60	105.70	46.90	17.10
Education	33.30	15.50	17.80	5.40
Health	18.80	4.20	14.60	6.70
Subtotal	***204.70***	***125.40***	***79.30***	***29.20***
Service sector				
Water and sewage	16.70	5.50	11.20	9.60
Electricity	17.10	15.10	2.00	15.40
Hydrocarbons (petroleum)	1.80	0.60	1.20	0.50
Subtotal	***35.60***	***21.20***	***14.40***	***25.50***
Transport sector (infrastructure)				
Highway infrastructure	785.10	96.00	689.10	52.10
Train	0.70	2.10	(1.40)	0.40
Telecommunications	1.00	1.00	-	0.70
Urban transport	7.80	3.00	4.80	0.30
Subtotal	***794.60***	***102.10***	***692.50***	***53.50***
Productive sectors				
Agriculture	1,186.80	538.70	648.10	351.10
Livestock	14.50	8.90	5.60	4.70
Fisheries	42.40	0.10	42.30	33.00
Industry	165.70	12.00	153.70	77.40
Commerce	36.30	19.10	17.10	3.80
Tourism	70.00	18.00	52.00	14.00
Subtotal	***1,515.70***	***596.80***	***918.80***	***484.00***
Prevention and emergency	**331.00**		**331.00**	**66.20**

1.2. State of Natural and Social domains: atmospheric. Terrestrial, oceanic, social, economic, legal and technological

Coastal Ecuador is divided into five provinces, four of them with coastal front. From north to south there are Esmeraldas, Manabi, Guayas and El Oro. The main socioeconomic activities respond to the climatic conditions, with the exception of petroleum exports through the Esmeraldas port in Esmeraldas Province.

The mean climate of the eastern tropical Pacific is dominated by the trade wind circulation, which is highly sensitive to and interacts with the underlying SST distribution. A dominant feature in the precipitation fields is the oceanic Intertropical Convergence Zone (ITCZ), which marks the convergence line between the northern and southern hemisphere trade winds (usually located north of the equator). Distinctive features of the climatology of this region also include: the equatorial cold tongue in the SST pattern and the equatorial asymmetry between the warmer, rainier area north of the equator and the cooler, drier region to the south. Schematics of the system are shown in figure 4.1, with the main current system depicted by the arrows. In blue is shown the annual temperature range, which is largest along the Peru –Chile and South Equatorial current axis. The extreme of the oceanic warming – cooling are the months of March and September respectively (Cornejo, 2003).

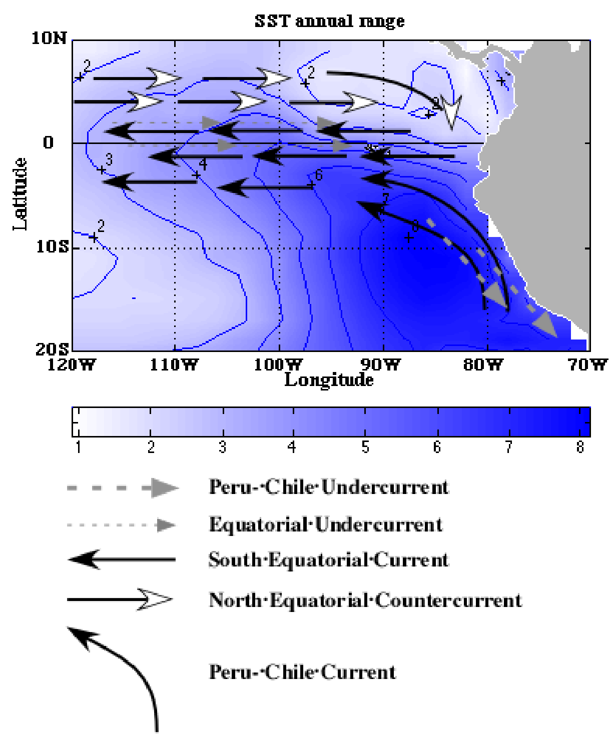


Figure 1.1 Current System in the Eastern Tropical Pacific and Annual temperature range.

A tri-dimensional view is shown in the schematics of figure 1.2. Surface easterly winds blow piling warm water on the western equatorial Pacific, and raising the thermocline in the eastern equatorial Pacific, generating a strong east-west temperature gradient. Convection develops over the warm waters near Australia and Indonesia, and thus rainfall.

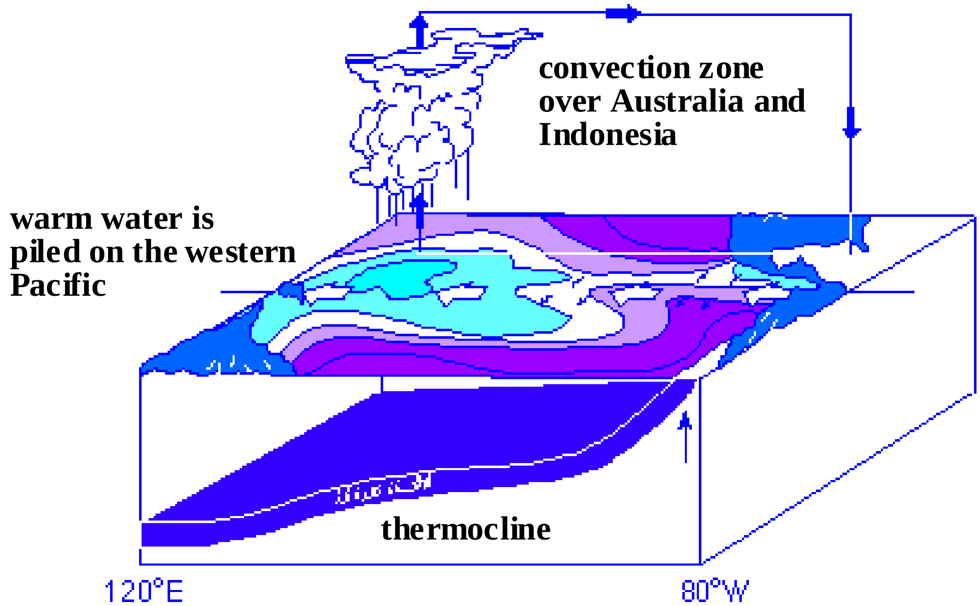


Figure 1.2 Normal ocean-atmosphere conditions in the Equatorial Pacific

The population in coastal provinces was about 5,406,045 in 2001 (2001 Population Census), excluding Los Ríos Province, which does not have a coastal front. It amounts for about 50% of Ecuador's population in 2001. Schooling is calculated as the average number of years approved by the population 10 years old and older at the different levels of instruction[1]. The average for the whole country is 7.1. Table 1.2 shows the basic population structure per province during the 2001 Population Census. It is important to mention that most of the artisanal and industrial fisheries take place in Guayas and Manabi provinces. In Esmeraldas the population uses the services of estuaries and mangrove area only for subsistence and for crabs and oysters catches (National Fisheries Institute, personal communication), with some aquaculture activity. El Oro province is mostly dedicated to banana farming and exports, as well

[1] In Ecuador the elementary and high school system amount for 7 and six years respectively by 2001. Today, the system has changed, and 2 years of pre-school have been added.

as shrimp aquaculture, and the artisanal fisheries are mostly for household consumption. Aquaculture activity in general is recovering from the 2000 white spot virus syndrome.

The Ecuadorian Program on Coastal Resources Management (PMRC in Spanish) developed a Proposal for Coastal Development and Planning that resulted in a publication on Macrozonification of the continental coastal zone (i.e. excludes Galapagos islands) (Ochoa, Olsen and Arriaga, 2001). This publication included public participation of the coastal zone (5km inland) and presents scenarios for 2010 and 2030. Figure 1.3 is taken from Ochoa, Olsen and Arriaga (2001, Chapter III). It shows the scenarios for 2010, and the small boats show the areas of artisanal fisheries; the big ships the industrial ports and the anchors the commercial ports. Most of the artisanal and industrial fisheries are located in Manabi and Guayas provinces.

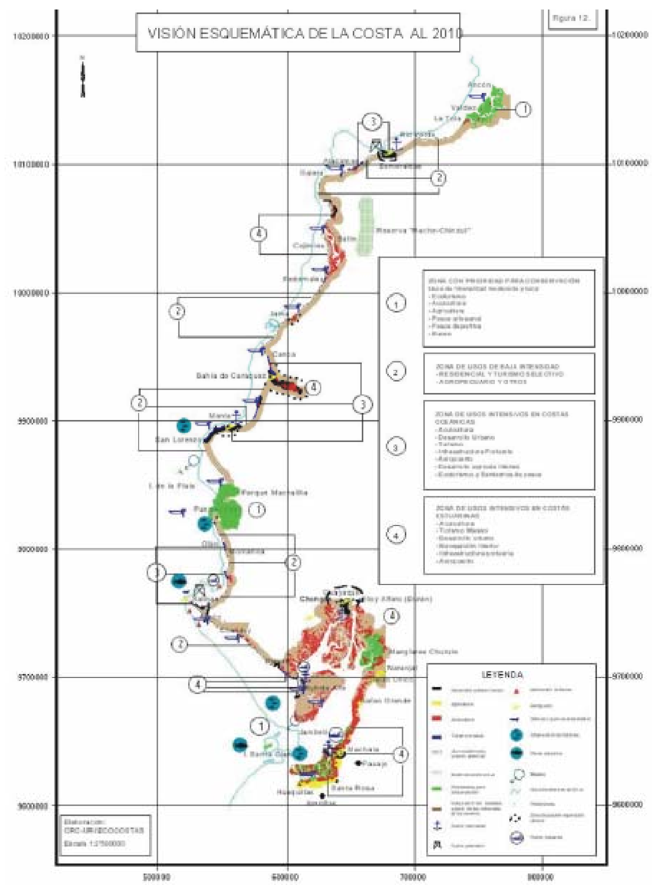


Figure 1.3 Schematic vision of coastal development by 2010. Taken from Ochoa, Olsen and Arriaga (2001, Chapter III).

Table 1.2 Population Structure in the Coastal Provinces and their main artisanal or industrial fisheries locations

Province	Total	Annual growth rate	Males	%	Females	%	(Male/female) *100	% Prov.	Total housing	Labor force	Agriculture, aquaculture, gaming and fisheries	Schooling rate
GUAYAS	3,309,034	2.5	1,648,398	49.8	1,660,636	50.2	99.26	100.0	865,562	1,220,389	200,547	7.1
BALAO	17,262	2.9	9,332	54.1	7,930	45.9	117.68	0.5	4,552	6,759		5.3
SALINAS	49,572	3.9	25,095	50.6	24,477	49.4	102.52	1.5	18,287	16,253		6.2
SANTA ELENA	111,671	2.6	57,343	51.3	54,328	48.7	105.55	3.4	30,996	35,750		5.6
PLAYAS	30,045	3.0	15,142	50.4	14,903	49.6	101.60	0.9	10,665	10,167		5.8
LA LIBERTAD	77,646	3.5	38,847.	50.0	38,799	50.0	100.12	2.3	19,711	26,104		6.4
GUAYAQUIL	2,039,789	2.4	999,191	49.0	1,040,598	51.0	96	61.6	520,789	780,268		8.0
MANABI	1,186,025	1.3	596,502	50.3	589,523	49.7	101	100.0	301,533	382,106	149,475	5.9
MANTA	192,322	3.4	94,486	49.1	97,836	50.9	96.58	16.2	47,546	66,244		7.1
PEDERNALES	46,876	3.9	24,358	52.0	22,518	48.0	108.17	4.0	11,713	14,343		4.1
PUERTO LÓPEZ	16,626	1.8	8,712	52.4	7,914	47.6	110.08	1.4	4,201	4,827		4.9
JAMA	20,230	6.4	10,312	51.0	9,918	49.0	103.97	1.7	4,129	7,006		4.4
JARAMIJÓ	11,967	3.6	6,150	51.4	5,817	48.6	105.72	1.0	2,473	3,439		4.6
SAN VICENTE	19,116	0.3	9,842	51.5	9,274	48.5	106.12	1.6	5,353	6,200		5.0
ESMERALDAS	385,223	1.7	197,150	51.2	188,073	48.8	105	100.0	100,620	129,655	48,111	5.8
ESMERALDAS	157,792	1.4	77,350	49.0	80,442	51.0	96.16	41.0	40,445	53,826		7.2
MUISNE	25,080	1.0	13,483	53.8	11,597	46.2	116.26	6.5	6,860	7,811		4.3
SAN LORENZO	28,180	2.0	14,675	52.1	13,505	47.9	108.66	7.3	7,185	9,874		4.9
ATACAMES	30,267	4.7	15,936	52.7	14,331	47.3	111.20	7.9	8,689	10,375		5.2
EL ORO	525,763	2.2	266,716	50.7	259,047	49.3	103	100.0	146,675	195,046	57,706	7.0
MACHALA	217,696	2.9	109,011	50.1	108,685	49.9	100.3	41.4	57,535	82,313		7.8

1.3. Evolution of the fisheries sector

During 2006 an important change in the legal framework for fisheries was approved. Prior to 2006, the fisheries sector was included within the Ministry of Foreign Affairs, Commerce, and Integration, formerly known as the Ministry of Commerce, Fisheries, Integration and Competitiveness. Today, the fisheries sector is under de Ministry of Agriculture and Fisheries (formerly known as Ministry of Agriculture) and changes in its structure are under development and implementation. The under-secretary of fisheries resources, which is located in Guayaquil (Guayas province), would move the city of Manta (Manabi province), and a new under-secretary for Aquaculture would be created and located in Guayaquil. This has posed some problems among the private sector because Guayaquil is the main export ports for fisheries products, while Manta concentrates mostly the tuna exports. The National Fisheries Institute is also undergoing a re-engineering process and it is currently in charge of the test that the European Union requires on Aquaculture products for exports.

A good overview of the fisheries sector in Ecuador is provided by FAO (http://www.fao.org/fi/fcp/es/ECU/BODY.HTM, document in Spanish). Some of the information provided in it, is shown here for completeness. In 1952, Ecuador along with Peru and Chile signed the Declaración de Santiago, to extend their national jurisdiction 200 nautical miles off their respective coasts, to preserve their marine resources. Afterwards, the Permanent Commission of the South Pacific (CPPS in Spanish) is created to develop research and protection of the marine resources. One of its most important results with the aid of FAO is the creation of the National Institute of Fisheries, with the Ecuadorian one (INP in Spanish), starting in 1960. The mission of INP is to conduct research on the ocean to generate enough knowledge for adequate management of the Ecuadorian fisheries. It is an advisor to the under-secretary of fisheries, providing the basis for management and regulation of the fisheries sector.

The most important fisheries landing ports are shown in figure 1.4 ((http://www.fao.org/fi/fcp/es/ECU/BODY.HTM); and their importance is shown in the average for the period 1990-1999 (table 1.3).

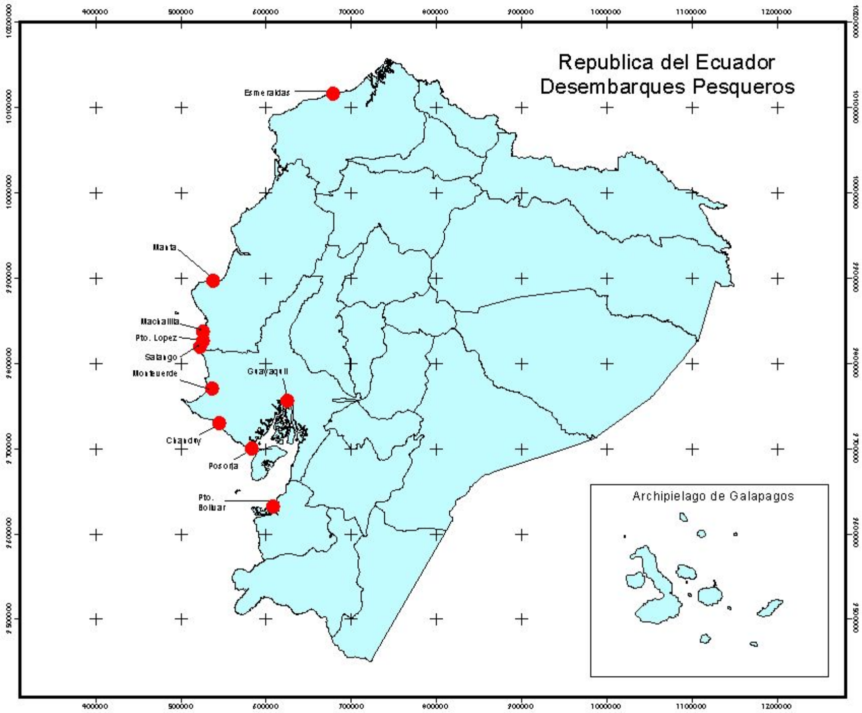


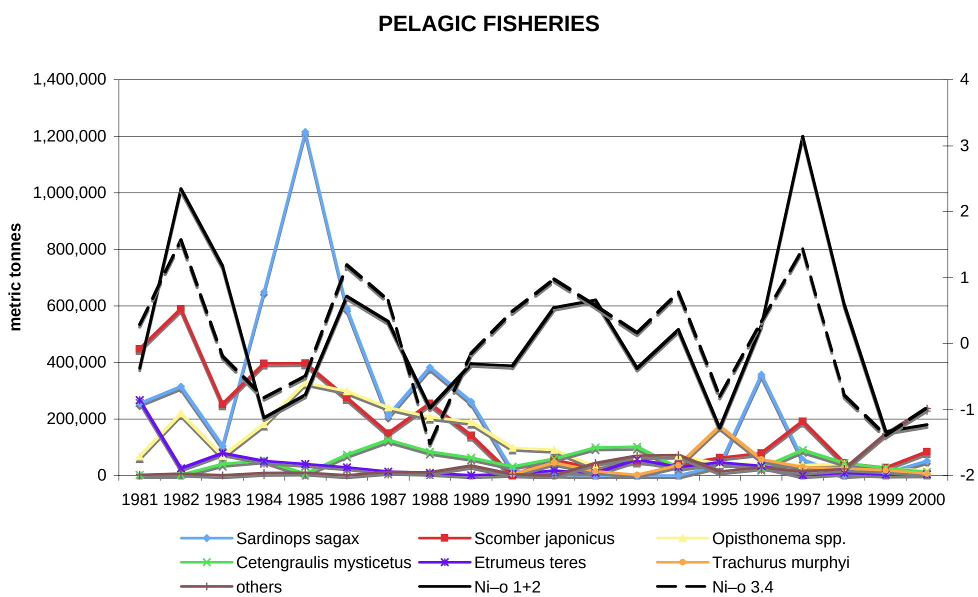
Figure 1.4 Main fisheries landing ports (red dots). Taken from (http://www.fao.org/fi/fcp/es/ECU/BODY.HTM)

Table 1.3 Main fisheries landing ports and average landings for the 1990-1999 period. Taken from (http://www.fao.org/fi/fcp/es/ECU/BODY.HTM)

Port	**Metric tones/year**	**%**
Manta (Manabí)	250,442	62
Guayaquil (Guayas)	84,827	21
Posorja (Guayas)	40,393	10
Monteverde (Guayas)	8,078	2
Chanduy (Guayas)	4,039	1
Esmeraldas (Esmeraldas)	4,039	1
Salango (Manabí)	4,039	1
Pto. López (Manabí)	1,615	0.4
Machalilla (Manabí)	1,615	0.4
Pto. Bolívar (El Oro)	4,039	1
Galápagos	813	0.2
Total	403,939	100

The industrial sector was initially dedicated to tuna and shrimp fisheries, and then also moved to include small pelagic fish such as sardines, and later fish for fishmeal. The tuna catches has been growing continuously since the seventies (Cucalon, 2005), from about a million metric tones in 1970 through close to 4.5 million metric tones in 2003. Cucalón (2005) shows in his Atlas of Tuna Fisheries in the eastern Pacific the effects of El Niño and La Niña events during the 1970-2003 period. By 2002, the Tuna industrial fisheries had 106 vessels, 33 canning factories, and 19 packing facilities. The Inter-American Tuna Commission regulates Tuna catches in the eastern Pacific.

During April 2007, a workshop on current fisheries results was held at INP. Gonzalez et al. (personal communication) in an analysis of the small pelagic fisheries for the 1981-2006 period show that the maximum catches were in 1985 with a total close to 2 million metric tones while the minimum registered was 175,000 metric tones during 2004. They also show that there is a tendency for alternating species catches and a general decreased in the availability of small pelagic fish. In figure 1.5 we show the pelagic fisheries catches for 1981-2000 (from http://www.fao.org/fi/fcp/es/ECU/BODY.HTM) along with two well-known climatic indices, Niño1+2[2] and Niño3.4 (black lines), and in table 1.4 we show its data.



[2] The Niño 1+2 and Niño3.4 are Sea Surface Temperature indices calculated the average temperature from 0-10°South, 90°West-80°West and 5°North-5°South, 170-120°West, respectively. The monthly departures are the anomalies from average of the period 1971-2000.

Figure 1.5 Total annual catches for small pelagic fishes. The black continuous and dotted lines are the Niño 1+2 and Niño 3.4 indices with an annual filter computed from their monthly values.

The total annual catches do not exhibit a specific pattern. The peaks in the climatic indices coincide with the ENSO events of 1982-83, 1986-1987, 1991-1992 and 1997-1998. Also take in account the warm period after the 1991-1992 ENSO events. Since we don't have fleet size, and hence yield, we cannot filter out over-fishing. However, figure 1.4 shows that the relationships between temperature anomalies and some species like *Sardinops sagax* and *Scomber japonicus* are inverse, and that long warming periods are associated with their decrease and disappearance.

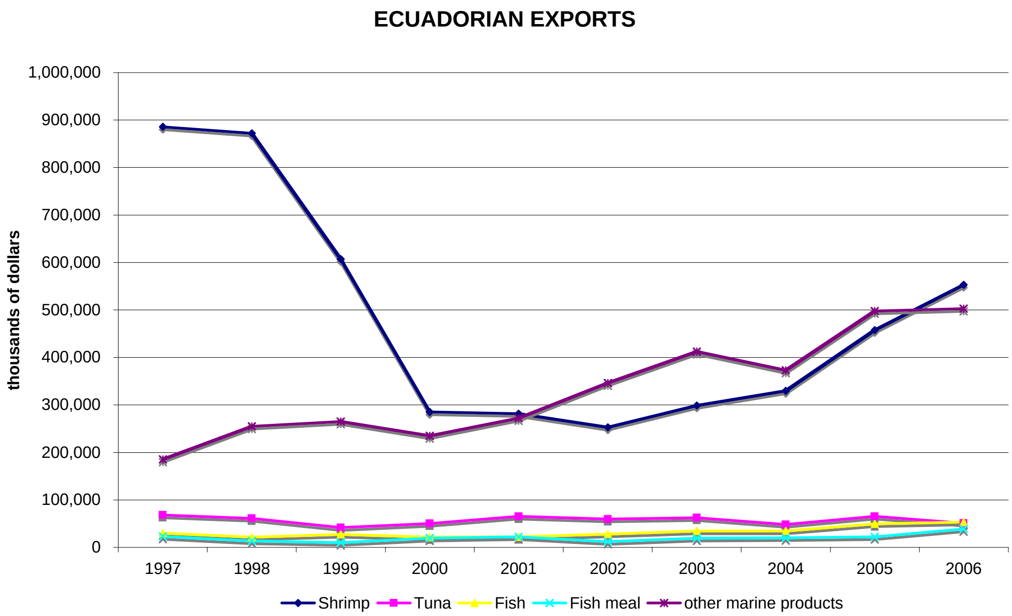


Figure 1.6 Main Ecuadorian Exports from fisheries and aquaculture. Source: Ecuadorian Central Bank (www.bc.fin.ec).

Figure 1.6 shows the main Ecuadorian exports from fisheries and aquaculture. During the last decade, Shrimp exports had a maximum during the 1997-98 ENSO event but fold dramatically, about to 1/3 of its value, due to the white Spot Virus syndrome, and remained there for about four years. After 2004, the shrimp sector is increasing its yield due to control of the virus and best practice management. During the same period tuna exports have more than doubled while other products remain about the same level.

Table 1.4 Total annual catches for small pelagic fishes. The Niño 1+2 and Niño 3.4 indices were filtered with an annual filter.

	Sardinops sagax	*Scomber japonicus*	*Opisthonema spp.*	*Cetengraulis mysticetus*	*Etrumeus teres*	*Trachurus murphyi*	**Others**	**Total**	**Niño 1+2**	**Niño 3.4**
1981	255,102	448,088	68,390	2,832	266,177		2,526	1,043,115	-0.3734	0.2919
1982	314,102	589,375	219,849	2,832	25,547		6,577	1,158,282	2.3455	1.575
1983	104,163	252,667	69,155	40,384	79,339		1,155	546,863	1.1786	-0.1928
1984	648,784	396,913	182,074	54,029	52,025		9,608	1,343,433	-1.1241	-0.818
1985	1,215,587	397,863	328,074	5,788	40,739		10,536	1,998,587	-0.7749	-0.4897
1986	590,258	274,852	297,721	74,246	29,209		1,215	1,267,501	0.719	1.1929
1987	210,097	149,302	240,577	126,420	14,373		12,899	753,668	0.3355	0.6554
1988	382,337	255,548	206,766	84,346	9,215		11,115	949,327	-0.9719	-1.5127
1989	260,872	141,333	189,789	63,433	838		35,108	691,373	-0.3076	-0.1434
1990	16,895	786	98,632	30,996	5,471	4,144	4,114	161,038	-0.3337	0.49
1991	3,377	55,023	91,622	59,637	17,180	45,313	392	272,544	0.5444	0.978
1992	212	25,651	31,016	99,672	9,688	15,022	45,000	226,261	0.6633	0.5774
1993	0	50,980	69,247	101,683	57,663	2,673	70,136	352,382	-0.3712	0.1639
1994	212	38,991	69,892	27,164	30,748	36,575	72,486	276,068	0.2102	0.7823
1995	34,609	63,577	40,910	47,660	46,253	174,393	14,532	421,934	-1.2795	-0.7988
1996	356,477	79,484	41,041	26,354	34,349	56,782	29,028	623,515	0.2751	0.3366
1997	56,096	192,181	37,723	89,723	1,095	30,302	14,389	421,509	3.1447	1.439
1998	1,012	44,716	40,530	44,474	8,873	25,900	23,580	189,085	0.5935	-0.7806
1999	8,821	28,307	22,253	27,221	3,636	19,072	146,970	256,280	-1.3351	-1.3867
2000	51,440	83,923	20,037	13,333	4,415	7,122	236,900	417,170	-1.2292	-0.9702
Total	4,510,453	3,569,560	2,365,298	1,022,227	736,833	417,298	748,266	13,369,935		

2. Risk and climate impacts facing Ecuador

2.1. Risk and climate impacts

The fisheries sector faces several problems regarding climate impact that must be taken in account:

1) Changes in air temperature and precipitation patterns.
2) Sea level rise: because of the gentle slope of the continental platform, and immediate coastal plains a small rise in sea level would result in increase of the surge area, coastal erosion and lost of the beach side. This in turn poses the question of adaptation through different kind of measures.
3) Changes in water masses (temperature, salinity and oxygen properties), and hence migration of fisheries because of changes in the habitats

2.2. The attribution problem

The main problem is that some of the impacts are exacerbated by the current socioeconomic conditions of the Ecuadorian population which are the result of the socio-political situation of the country in at least the last ten years plus the effects of lack of enforcement of coastal management policies regarding land use, zonation and sustainable use of ecological services as well as sanitation and provision of potable water in small settlements and rural areas.

3. Fisheries sector key vulnerabilities at household, community and national levels

The fisheries sector key vulnerabilities at the household, community and national level, have been previously analyzed by different governmental agencies under their own perspectives. The Ministry of Environment (Cáceres, 2001) conducted an study on Vulnerability, Adaptation and Mitigation of Climate Change which included An evaluation of the Vulnerability of the coastal zone of the Gulf of Guayaquil (Guayas Province) only; Ochoa, Olsen and Arriaga (2001) prepared scenarios for 2010 and 2030 for locations within 5km from the shoreline related to coastal planning; and IPUR-Catholic University (2001) prepared for COPEFEN (unit Coordinating Emergency Plans to cope with ENSO) and IDB a plan of the infrastructure required to cope with ENSO events at the coast. These three works combined help us to understand which are the key vulnerabilities of the fisheries sector under the assumption that climate change scenarios will be similar to those of ENSO events warm an cold phases and that direct negative impacts are the three mentioned in section 2.1.

We did not find any study that really assess vulnerability due to sea level change, changes in temperature and precipitation patterns, and changes in water masses in both the artisanal and sssindustrial fisheries. It is probable that impact on the industrial fisheries would fall into new regulations of the Tuna fisheries in the Pacific and that migration under adverse oceanic conditions would pose an increase in mobility expenses (fuel expenses). The problem with impacts on the artisanal sector is that National Fisheries Institute (INP, personal communication) does not have enough funds in its budget to regularly visit all the artisanal fisheries settlement for data collection. INP's director proposed the artisanal fishermen, in a recent meeting, to establish a cooperation scheme in which they report to the INP their fisheries data. Currently, the Ecuadorian National Meteorological and Hydrological Services (personal communication) are analyzing model results for climate change scenarios in 10, 30 and 100 years from current time.

In reality vulnerabilities to climate change at different levels are due to insufficient implementation of coastal planning, political and economical crisis and social conflicts. Ochoa, Olsen and Arriaga (2001) prepared a scenario for the coastal zone for 2030 under the assumption that the same conditions (as in 1970-2000) hold through that year. The assumptions are:

- Annual population growth for the coastal provinces is 3% and for the coastal cities between 3-5%.
- The election system and its expenses would be the same, and hence the political and economical crisis and social conflicts would continue.
- Because of social instability it would not be possible to implement a national agenda for coastal management

Then the vulnerabilities (results) would be as follows:

- Estuarine productivity would be destroyed in terms of fish population, crustacean and mollusks plus shrimp aquaculture due to water pollution and changes in fresh water fluxes
- Pressure over less affected areas would increase as well as illegal activities, making others such as aquaculture unsustainable
- Housing and tourism development would be chaotic and artisanal fishermen

would loose direct access to the beaches.

The activities proposed by the main actors in each of the provinces (Ochoa, Olsen and Arriaga, 2001) are related to the previously mentioned vulnerabilities. A digital version of Ochoa, Olsen and Arriaga (2001) is attached as Annex.

The vulnerability identified by IPUR (2001) relates to infrastructure (this is the scope of CORPECUADOR): riverbank protection, flood protection, landslide protection and it has been identified to the level of suburbs/neighborhood. A summary of the requested investment to reduce vulnerability is shown in the following table (table 3.1), and the complete document in Spanish is in the Annex.

Table 3.1 Works demanded to cope with vulnerable areas of the coastal Provinces

Province	Number of works requested	Preventive short term worked		Works that demand studies	Works without enough information
		Number	Cost ($)	Number	Number
Esmeraldas					
Manabi	227	63	2,221,747	108	56
Guayas	349	107	1,674,851	206	36
El Oro	186	76	1,643,909	91	19

The results from the analysis, led by Cáceres (2001), regarding adaptation strategies in the lower Guayas river basin and Gulf of Guayaquil, show that vulnerabilities for the fisheries sector are related to flooding of coastal settlements due to sea level rise, loss of biodiversity because of lost of mangrove areas, and changes in the trophic chain structure that would in turn affect the fisheries (small pelagic fish and the so called white fisheries), decreasing the stocks and putting more pressure on the remaining resources. Also, since most of the shrimp farms are located in this area, sea level rise would have a negative impact on the infrastructure of the sector, as well as a decreased in oceanic temperatures. Effects in other sectors have also been identified. A digital version of Cáceres (2001) is attached.

4. ENSO: a climatic extreme event and its impact upon the fisheries sector

El Niño/Southern Oscillation (ENSO) was one of the best well known climatic extremes in Ecuador. The pre-Columbian El Niño knowledge presented it as a climatic warm event, that periodically appears during the rainy season (around the end of December) in southern coastal Ecuador and northern coastal Peru. This climatic event was associated with fertility, because of the increase in rainfall associated with it (Marcos, 2004). During the twenty century, the concept of ENSO evolved from a local process (local to Ecuador and Peru) to an equatorial Pacific basin-wide event with worldwide teleconnections, along with positive and negative impacts. Currently, during the twenty-first century, the ENSO events have been limited to the central equatorial Pacific Ocean, with little signature and impact over coastal Ecuador and Peru. This evolution of ENSO events through the centuries implies that we have to study it in relationship to longer time scales of variability, associated with multi-decadal to centennial variability in order to understand its changing behavior. However, in lieu of climate change, the scenarios posed by both the warm - El Niño-, and the cold – La Niña -, phases are still useful as climate extremes that could occur under climate change conditions under the assumption that the climatic extremes would become more frequent.

There are several studies looking at the impact of ENSO upon different socioeconomic sectors, such as agriculture, fisheries, and also upon infrastructure and health. In the case of fisheries, there should be four aspects taking into consideration (there are not in order of importance):

i) Changes in fisheries due to migration or decay of a population because of oceanic conditions
ii) Impact of sea level change (mainly rise) on the coastal fisherman settlement
iii) Impact of the infrastructure use to transport the catches from the different fisheries
iv) Impact on the health of the coastal populations

All this impacts, positive or negative would influence the fisheries sector under climate change conditions. The following scenarios are provided as means as understanding what could happen under extreme events.

General aspects

4.1. ENSO warm phase scenarios

ENSO warm phase scenarios are well known and their worldwide impact has driven the attention of stake-holders and policy-makers, who at the end of the last century implemented a series of programs for end-users to cope with their negative impacts and taking advantage of the positive ones. General schematics of the ocean-atmosphere conditions during the event are shown in figure 4.1. In contrast, with figure 4.2, at some point in the equatorial Pacific (in space and time), the easterly winds relaxed and the warm water that was piled on the west moves eastward. The thermocline depth increases, and the convection move also eastward with the warm waters underlying it. A set of Kelvin waves transport energy eastward rising sea level on the equatorial waveguide off South America (usually between 5°N-5°S), generating coastal-trapped waves that move poleward, rising sea level along the west coast of the Americas (Cornejo and Enfield, 1987; Enfield et al., 1987).

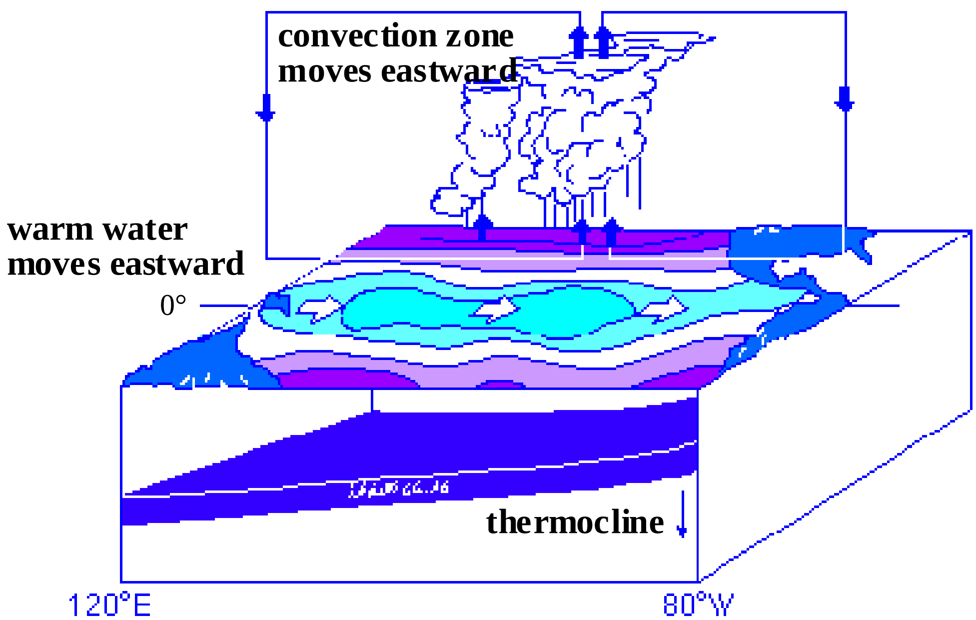


Figure 4.1 ENSO conditions in the equatorial Pacific

A well-known scenario for South America is the one depicted in figure 4.2, with the impact in precipitation (wet or dry) and air temperature (warm or cold). Off Ecuador, conditions are usually wet and warm, but their strength depends on the timing of the onset of the warm event.

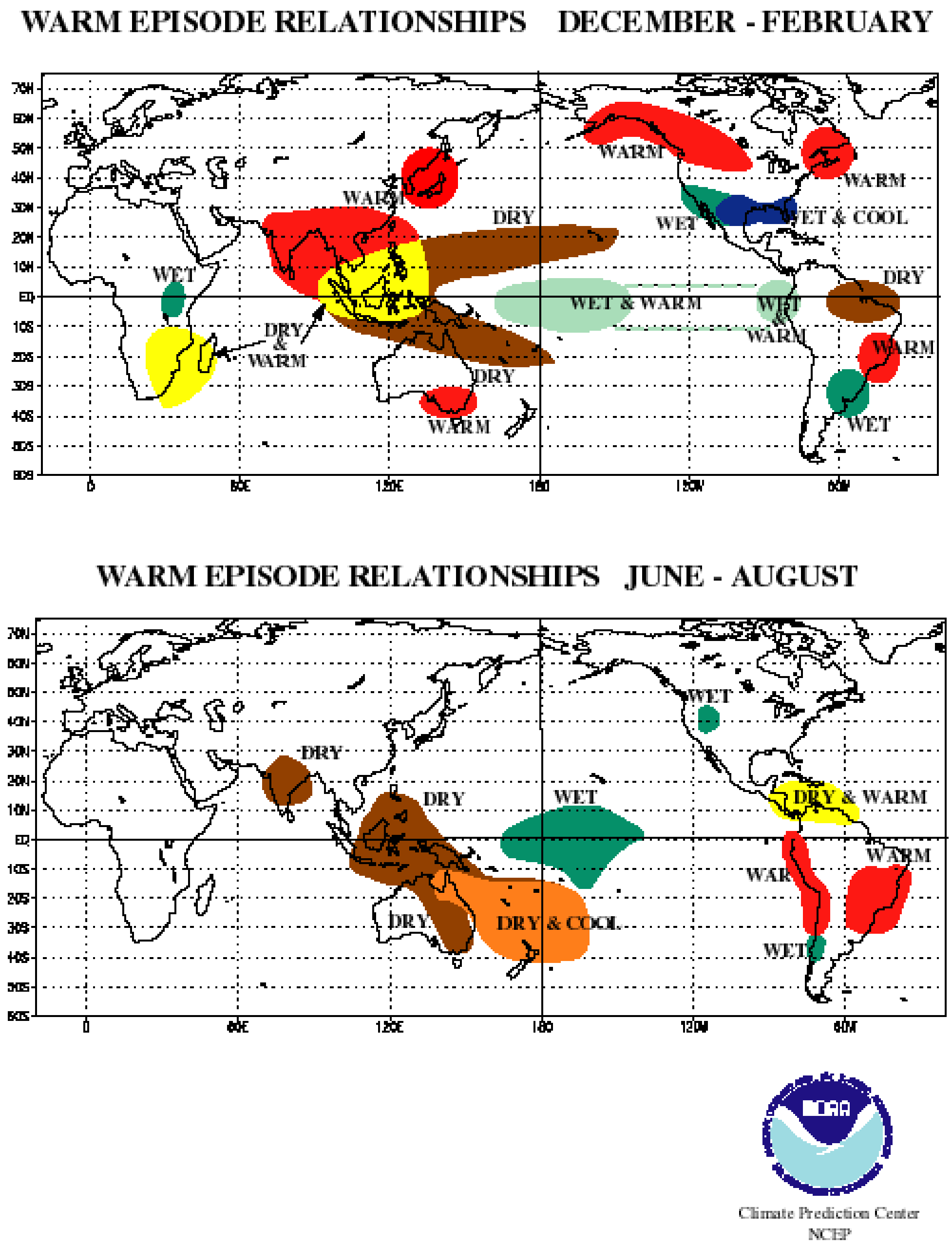


Figure 4.2 ENSO warm phase known impacts. Source: http://www.cpc.noaa.gov/products/analysis_monitoring/impacts/warm.gif

The damage in the fisheries as an important socioeconomic sector was analyzed by CAF (2000). In total during the 1997-1998 ENSO event, the total damage was 42.4 million dollars (table 1.1), direct damage about 0.1 million dollars, indirect damage 42.3 million dollars and the effect over the payment balance was about 33 million dollars (decrease in exports in relationship to imports). The total is about 1.47% of the total damages in the country (table 1.1). For comparison, damages during the

1982-83 ENSO event in the fisheries sub-sector were 117.2 million dollars (ECLAC, 1983), i.e. there was a reduction of almost 1/3 in losses from this event to the 1997-1998 one (table 4.1). For 1982-83 most of the damage was due to reduction in catches (113.2 million dollars; ECLAC, 1983). A detailed list of impacts per hydrographic basin is presented in CAF (2000), but without their costs.

Table 4.1 Damage caused by the 1982-83 ENSO event in millions of dollars. Adapted from ECLAC (1983)

Sector, subsector and item	Total damage	Direct Damages	Indirect Damages	Effects over the payment balance (exports/imports)
Total	**640.6**	**533.9**	**106.7**	
Social sectors				
Housing	6.3	6.3	-	1.2
Education	6.6	5.8	0.8	1.1
Health	10.7	4.6	6.1	7.7
Subtotal	***23.6***	***16.7***	***6.9***	***10***
Transport				
Highway infrastructure	162.0	126.4	35.6	77.3
Train	16.7	14.9	1.8	8.5
Airport infrastructure	4.1	4.1	-	1.9
Urban transport	26.5	18.9	7.6	13.1
Subtotal	209.3	164.3	7.6	***100.8***
Productive sectors				
Agriculture	202.7	202.1	0.6	94.3
Livestock	31.1	22.1	9.0	4.5
Fisheries	117.2	117.2	-	
Industry	54.6	10.0	44.6	
Subtotal	***405.6***	***351.4***	***44.6***	***98.8***
Other damages	**2.1**	**1.5**	**0.6**	**0.6**

The local impacts follow:

i) Sea level rise: during the extreme events of 1982-83 and 1997-1998 sea level rise between 0.20-0.40 m above the average causing coastal erosion at the shoreline, destroying structures near the beach. It also caused problems to the artisan fisherman boats, losses in tourism at the beaches, and beaches were crowded with dead trees and animals at their estuarine outlets. The DIVA[3] software (it is an integrated assessment

[3] DIVA is a new tool for integrated assessment of coastal zones that will be released in late

model to assess the vulnerability of the coastal zone worldwide, sea reference) was used to forecast sea level rise under scenario A1B, high sea level rise conditions. The results are shown in figure 4.3. The black line shows the 0.20 m level rise that occurred during the 1982-83 ENSO event. All coastal provinces and Galápagos Island are affected between 2030 and 2035, except Guayas that is affected between 2025 and 2030. This has to be used only as a reference since uplifting or subduction by plate tectonics is not taken into consideration in the DIVA software.

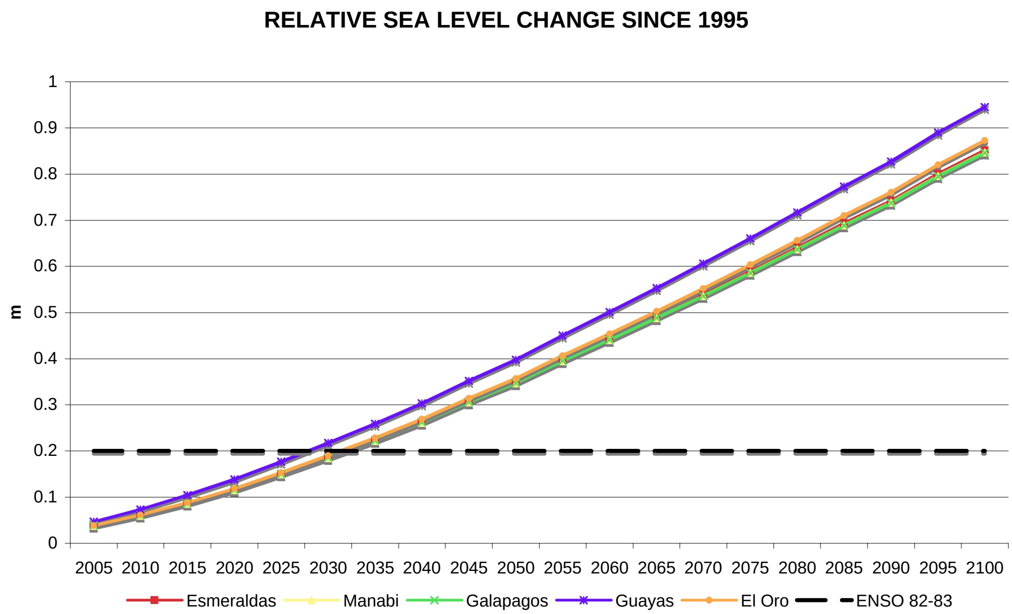


Figure 4.3 Relative sea level change since 1995 (as computed with DIVA software).

The population actually flooded is shown below (figure 4.4 and table 4.2). The province most affected is Guayas because of higher sea level rise (figure 4.3) and because it hosts about 25% of the country population and about 50% of the coastal area one. However, when we look at the numbers estimated by DIVA software (table 4.2 and compared then with those of table 1.2, there are very low in comparison with the actual population. The cost of adaptation as computed by DIVA is between 40 million dollars in 2005 to 250 million dollars by 2100. Impact/adaptation algorithms

2004. It is specifically designed to explore the vulnerability of coastal areas to sea level rise. It comprises a global database of natural system and socioeconomic factors, relevant scenarios, a set of impact-adaptation algorithms and a customized graphical-user interface. Factors that are considered include erosion, flooding salinization and wetland loss. DIVA is inspired by the paper-based Global Vulnerability Assessment (Hoozemans et al., 1993), but it represents a fundamental improvement in terms of data, factors considered (which include adaptation) and use of PC technology.

(Hoozemans et al., 1993) are used to compute these costs. There is not information about what would be the adaptation measurements in the model. Also, during the period 2000-2007, the sector most affected by climate variability in Ecuador has been the agricultural one (changes in precipitation patterns). The impact on the fisheries sector has not been accounted for. There is information (Townsend, personal communication), that the industrial fleet has been changing the size of the mesh (decreasing it), and changing fishery practices to be able to catch something. Simultaneously, due to decrease in some of the fisheries, the Ecuadorian government has explicitly banned some of the catches to go for fishmeal (e.g., *Cetengraulis mysticetus*).

Table 4.2 Forecast of people flooded by relative change in sea level shown in figure 4.3 (as computed with DIVA software) in thousands of people.

Year	**Esmeraldas**	**Manabi**	**Galapagos**	**Guayas**	**El Oro**
2005	0.07	0.18	0.01	3.74	0.23
2010	0.15	0.37	0.03	7.73	0.48
2015	0.24	0.57	0.04	11.96	0.74
2020	0.33	0.78	0.05	16.43	1.02
2025	0.42	1.00	0.07	21.10	1.31
2030	0.52	1.23	0.09	25.94	1.61
2035	0.62	1.47	0.10	30.93	1.92
2040	0.72	1.71	0.12	36.04	2.24
2045	0.82	1.96	0.14	41.23	2.56
2050	0.93	2.22	0.15	46.47	2.89
2055	1.04	2.47	0.17	51.74	3.21
2060	1.14	2.73	0.19	57.00	3.54
2065	1.25	2.99	0.21	62.23	3.87
2070	1.35	3.24	0.22	67.40	4.19
2075	1.46	3.49	0.24	72.50	4.50
2080	1.56	3.74	0.26	77.50	4.81
2085	1.66	3.98	0.28	82.39	5.11
2090	1.76	4.20	0.29	87.14	5.41
2095	1.85	4.42	0.31	91.71	5.69
2100	1.94	4.63	0.32	96.12	5.96

In Ecuador’s National Climate Change Communication, Cáceres (2001) used three different scenarios for sea level change, precipitation and air temperature changes in the Guayas river basin (it is part of the Guayas province and seven more provinces). In this case, the size of the population that most evacuated by 2010 is about 327,000 while under danger there 200,000 more. The losses are computed as 1,045 million dollars of losses and another 1,040 million dollars under danger. The difference between Cáceres (2001) and the results from the DIVA software is that in the former case, sea level change is not the only factor and it takes in account the river basin (an area of about 630 km perimeter and an area of14.878 km2, 1/3 covered by estuaries). Changes in temperature and precipitation would cause changes in precipitation patterns and hence flooding. Cáceres (2001) estimated the adaptation measures that must be taken, but they were not quantified. The main barriers for adaptation found were the institutional constraint, governance problems, power abused and financial constraints.

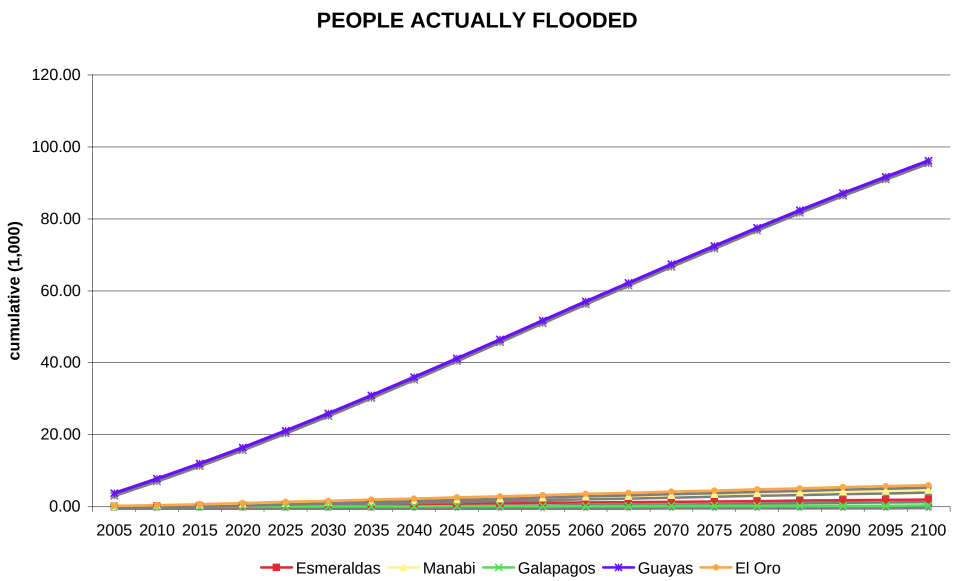


Figure 4.4 Forecast of people flooded by relative change in sea level shown in figure 4.3 (as computed with DIVA software).

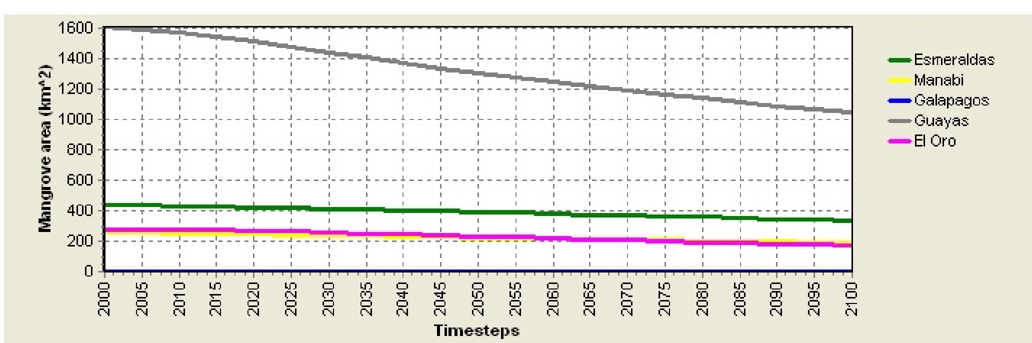


Figure 4.5 Forecast of mangrove area lost by relative change in sea level shown in figure 4.3

There are two more problems derived from sea level rise, salinization of groundwater and mangrove lost. There is not a good account of groundwater availability. Mangrove lost has also been forecast with DIVA Software and is shown in figure 4.5. Losses (not shown) in monetary value amount about 5 million dollars in 2000, and go up to over 140 million by 2100.

v) Changes in fisheries due to migration or decay of a population because of oceanic conditions.

Cucalón (2005) has analyzed the impact of ENSO warm phase upon the tuna landings in the eastern Pacific. He founds that catch per unit of effort decreases during ENSO events for almost the first three quarters of the second year of El Niño, with the stocks moving northward and eastward during 1982-83 and southward during 1997-1998.

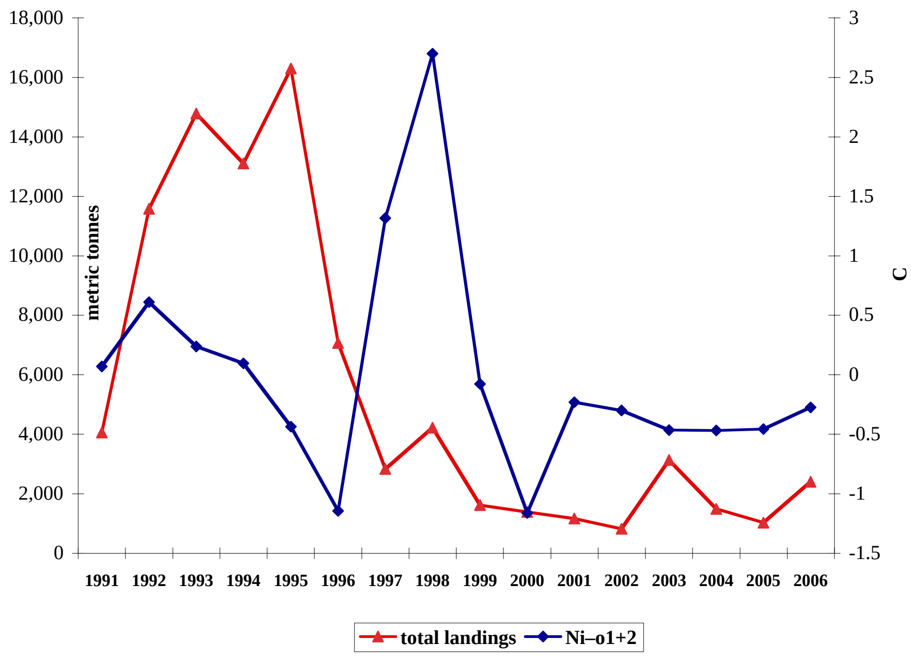


Figure 4.6 Tuna landings (metric tones) by artisanal fisheries (Source: INP 2007) and the Niño 1+2 SST index.

Table 4.1 Tuna landings by the Artisanal Fisheries. Source: INP 2007.

year	Esmeraldas	Manta	S. Mateo	Anconcito	Sta. Rosa	Playas	Engabao	Pto. Bolívar	TOTAL
1991	24.4	1612.9	1135.0	691.8	507.8	9.4	0.1	79.8	4061.2
1992	56.7	2583.3	2142.0	2926.7	3546.6	0.3	0.2	322.9	11578.7
1993	32.7	1302.8	1933.9	4969.1	5636.4	8.3	2.1	903.7	14789.0
1994	604.8	4333.1	1073.4	2901.4	3431.3	8.2	2.1	747.2	13101.5
1995	439.1	11628.2	396.8	2566.9	799.9	0.0	0.0	473.5	16304.4
1996	1650.0	3416.8	207.4	1534.7	108.8	0.1	0.0	147.1	7064.9
1997	12.3	2283.7	123.9	176.4	196.8	0.0	0.0	36.5	2829.6
1998	43.6	2539.1	20.8	1138.6	258.7	1.2	3.4	214.9	4220.2

1999	235.3	---	---	1340.4	37.6	1.5	1.7	0.0	1616.5
2000	230.0	47.8	---	862.2	56.3	54.8	2.8	135.0	1388.9
2001	5.3	368.4	---	488.9	138.4	0.0	0.2	168.5	1169.7
2002	76.2	---	17.2	43.9	532.1	0.1	0.0	155.3	824.9
2003	48.5	1244.2	128.6	88.9	1467.4	1.6	8.3	152.2	3139.8
2004	115.1	716.3	---	27.3	588.6	---	---	39.7	1487.0
2005	160.7	169.9	---	34.5	500.9	---	---	164.6	1030.7
2006	213.0	635.0	---	195.7	1160.8	---	---	206.6	2411.1

The Tuna landings by artisanal fisheries do not show a clear relationship with ENSO warm phases (figure 4.6 and table 4.1). However, for the 1991-2006 period an increase in landings is observed during warm periods.

As mentioned before, there is not clear relationship between warm phases of ENSO and pelagic fisheries (table 1.4 and figure 1.5). It seems that their variability is associated most probably with longer scales of variability and over-fishing.

In general, it would be more adequate to analyze all the fisheries off the west coast of South America, as part of the Peru-Chile upwelling ecosystem and the warm waters from the North Equatorial Countercurrent.

vi) Impact of the infrastructure use to transport the catches from the different fisheries

The coastal infrastructure (highways) is usually impacted by ENSO events. During the 1997-1998 ENSO event, transport cost (UNEP/NCAR EL Niño Project report) went up during December 1997, as result of the speculation. The transport system assumed that damages to the coastal infrastructure would be the same as during the 1982-83 ENSO event. Real damage occurred after January 1998. A new governmental entity was created to take care of the damages, CORPECUADOR. It is an executive unit devoted to rebuild the zones affected by ENSO. It was created in 1998 for a period of 10 years. The area covered by CORPECUADOR is about 100,000 km2, and includes everything below 1000m heights from the west Andean Mountains towards the coastal plains. Infrastructure and housing damages were closed to 900 million dollars (table 1.1), with over 13,000 houses affected (table 4.2, for all the coastal region). There are several maps that show (in Spanish) all the highway and bridges repaired by CORPECUADOR. They are only shown (figure 4.7) for the coastal provinces of Esmeraldas, Manabi, Guayas and El Oro. It is easy to compare the main landing ports listed in table 1.2 with the area covered by CORPECUADOR.

Table 4.2 Summary of victims and damage attributed to the 1997-98 ENSO event. This is table 17 in the ECUADOR, UNEP/NCAR EL NIÑO PROJECT REPORT. The coastal provinces with coastal frontlines have been highlighted. The total for the coastal region includes Los Ríos Provinces.

PROVINCE	DAMNIFICATED		AFFECTED		DEATH	WOUNDED	DISAPPEARED	HOUSES	
	FAMILIES	PEOPLE	FAMILIES	PEOPLE				AFFECTED	DESTROYED
AZUAY	36	175	136	703	6	3		120	35
BOLIVAR	5	21	56	277	14			54	5
CAÑAR	21	210	8	147	3		1	8	21
COTOPAXI	17	91	68	286	5		1	75	17
CHIMBORAZO	75	358	241	1,167	14	7	6	221	66
EL ORO	441	2,046	1,434	5,531	7		1	2,116	440
ESMERALDAS	571	2,446	744	1,678	31	40	7	596	533
GUAYAS	2,597	11,874	5,113	24,618	43	8	10	1,885	1,415
IMBABURA	1	5	4	20				4	1
LOJA	17	90	149	745	30	12		152	17
LOS RIOS	104	496	742	3,478	17	5	1	715	99
MANABÍ	1,863	8,768	3,050	15,776	104	81	5	3,050	1,863
MORONA SANTIAGO			14	75	3		2	14	
NAPO	347	2,046	1,345	6,755	3	2		862	347
PASTAZA	98	462	67	333	2	3		121	88
PICHINCHA					1				
TUNGURAHUA	1	3							1
ZAMORA CHINCHIPE	121	402	117	387	10	1	4	136	121
GALÁPAGOS	2	11	4	30				4	2
COUNTRY'S TOTAL	**6,317**	**29,504**	**13,292**	**62,006**	**293**	**162**	**38**	**10,133**	**5,071**
COASTAL REGION TOTAL	**5,578**	**25,641**	**11,087**	**51,111**	**202**	**134**	**24**	**8,366**	**4,352**
COASTAL REGION AS %	**88%**	**87%**	**83%**	**82%**	**69%**	**83%**	**63%**	**83%**	**86%**

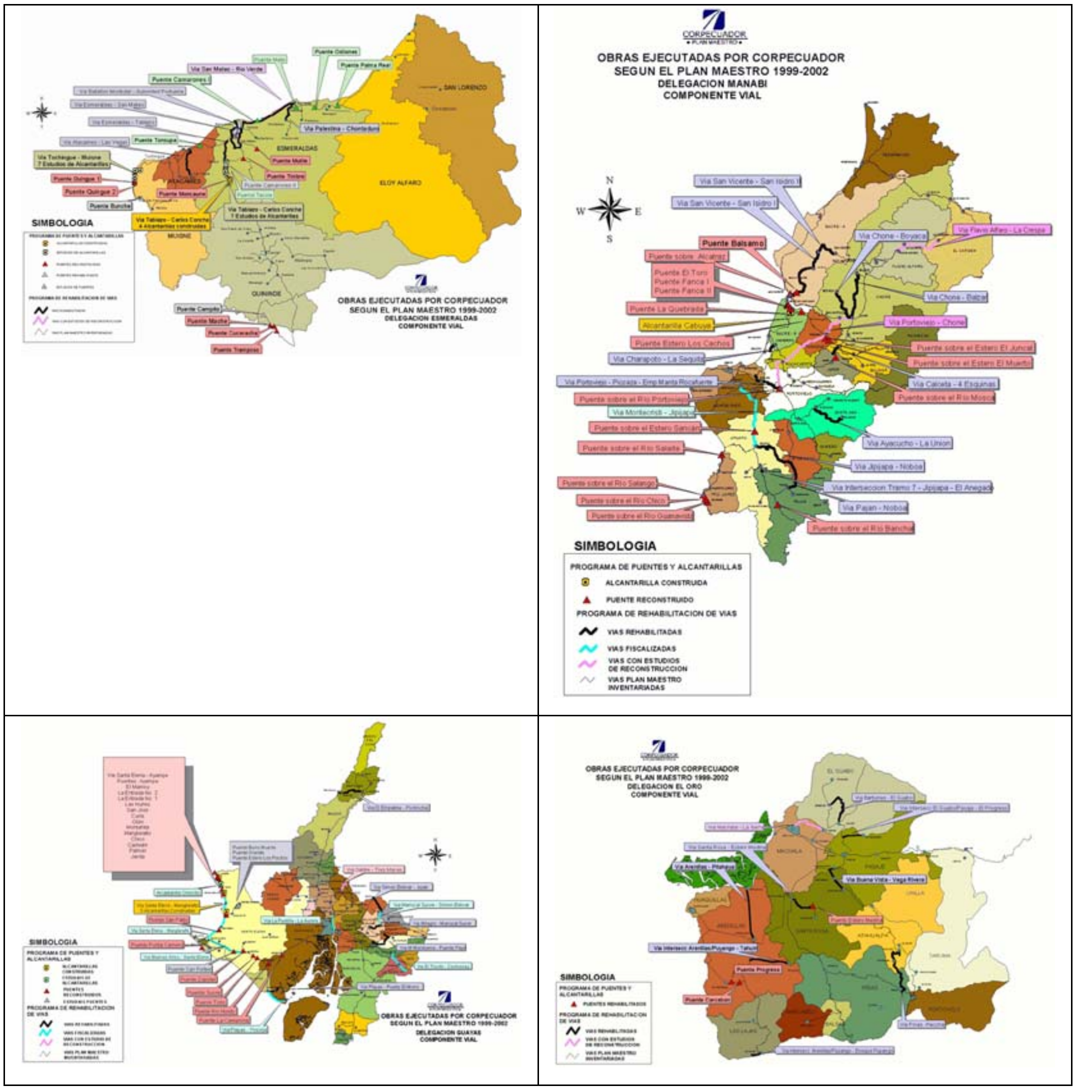


Figure 4.7 Infrastructure rebuild by CORPECUADOR during the 1998-2002 periods in the coastal provinces of Esmeraldas (upper left), Manabí (upper right), Guayas (lower left) and El Oro (lower right). Source: http://www.corpecuador.org/obras.htm.

vii) Impact on the health of the coastal populations

In Ecuador several diseases have been associated with ENSO periods: *V. cholerae*, *Campylobacter*, *C. botulinum*, *E. coli*, *Salmonella*, *Shigella*, Hepatitis A, Malaria, Dengue, Leptospirosis, Leishmaniasis, Encephalitis, among others.

Cholera appeared in the Americas in January 1991 and until 1997 there were over 1.3 million cases and more than 12 thousands dead. The maximum dispersion period occurred during the 1997-98ENSO, especially at the coastal communities. Several disease outbreaks coincide with climate variability, flooding, socio-political problems such as migration of displaced people or refugees towards areas of major economical development and lack of sanitation. The list includes: Malaria and Dengue (in the eighties and nineties), Dengue 3, an increase in Hemorragic Dengue, and the appearance of a new vector, *Aedes albopictus*,.

The most frequent pathologies related to some climatic events are listed below in table 4.3. There were 4 big epidemic problems during the last ENSO (1997-98): cholera, leptospirosis, dengue and malaria, which were enhanced by ENSO. The number of cases is depicted in table 4.4, at the coastal provinces. In table 4.5 we have the number of cholera cases during the 1991 and 1997-98 ENSO events for comparison. Notice that the cholera cases during the 1991-92 ENSO were higher than those of the 1997-98 one, so the magnitude of an event is not an indication of its impact upon a disease.

Table 4.3 Most frequent pathologies related to climatic events (from UNEP/NCAR EL NIÑO, 2000)

AREA	**DISEASES/ HEALTH PROBLEMS**
FLOODING	• Acute respiratory infections • Acute diarrheic diseases • Vector-borne diseases: dengue, malaria, equine encephalitis, leishmaniasis • Water-borne diseases: cholera, salmonelosis, shigellosis, viral hepatitis, parasitism, leptospirosis • Dermis diseases: sarna, bacterial infections and mycosis • Snake bites • drowning
DROUGHT	• Vector borne diseases • Dermis diseases • Dehydration • Risk due to high temperature • Sun burnt • Secondary effects: cardiovascular and respiratory ones
MUDSLIDES	• Suffocation • Multiple traumatisms
COASTAL AREAS	• Paralytic food poisoning from eating seafood (red tides)

Table 4.4 Diseases in coastal provinces attributed to the 1997-98 ENSO (number of cases registered) (from UNEP/NCAR EL NIÑO, 2000)

PROVINCE/ DISEASES	CHOLERA	DENGUE	MALARIA	LEPTOSPIROSIS[4]
GUAYAS	144	231	332	
MANABÍ	489	1285	1002	139
ESMERALDAS	1	1285	2077	
EL ORO	129	714	2867	1

One of the reasons for this dramatic decrease could be the Contingency Plan of the Public Health Ministry for prevention of epidemiological diseases such as malaria, cholera, dengue and leptospirosis implemented during the 1997-98 event. It is not possible to disaggregate the data into each of the coastal settlement for two reasons: firstable, some people go for treatment to the nearest health center which maybe in one location; and secondly, others go to private doctors who don't have an obligation to report any case.

Table 4.5 Cholera cases by province

PROVINCE	ENSO 1997-98	ENSO 1991-92
Guayas	457	4585
El Oro	303	4278
Esmeraldas	12	4081
Manabí	383	1432

4.2 ENSO cold phase scenarios

ENSO cold phase scenarios are commonly known as La Niña events. It was assumed during the past century that La Niña events were the opposite of ENSO events. However, this is not the case. Cedeño et al (2006), show that the impact upon precipitation in coastal Ecuador, below 1000m above sea level (the height the influence of ENSO) is not the opposite of the El Niño warm phase during La Niña.

In general, for the fisheries sector the impacts of La Niña cold events are positive. There is not sea level rise, hence there are not problems with coastal erosion. The main impact is on the agricultural sector because of decrease in precipitation and in the health of the population, because La Niña is associated with droughts. Table 4.3

lists the main health problems associated with droughts. In rural communities, an important problem could be water availability for human consumption. However, in contrast with ENSO warm phases, there is little information about the impacts of La Niña, cold phase.

The main changes observed in Tuna fisheries by the industrial sector as reported by Cucalón (2005) are an increase in the catch per unit effort observed during the 1988 La Niña in the eastern Pacific, with an increase of 15% in yellowfin catches and 50% in skipjack. He also found, that during cold events the stocks move northward and eastward. In the case of Tuna fisheries by the artisanal sector (figure 4.6), a decreased in the catches follows the decrease in temperatures during 1996 and 2000.

For the pelagic fisheries, there is not a unique relationship, some species have a positive relationship with decrease in oceanic temperatures, and others a negative ones. However, INP personnel (personal communication) believe that in general cold periods favor the development of most of Ecuadorian fisheries.

4.3 Pacific Decadal Oscillation scenarios

Fisheries time series are not long enough (at the most 20-25 years) to analyze the impact of Pacific Decadal Oscillation (PDO) upon fisheries resources in Ecuador. The longest time series belong to the INP. However, during the execution of the present study the INP database collapsed and they are in the process of recovering. What do we know is that during its positive (warm) phase ENSO warm phases are enhanced and extreme events are more frequent, and that during its negative (cold) phase La Niña cold phase would be enhanced and ENSO warm phases would be reduced. During the current century, ENSO warm events impacts have been reduced at coastal Ecuador and Peru, and they have been more limited to the central equatorial Pacific. The author suggests that research in this area must be conducted to understand implications for long-term sustainable fisheries development.

4.4 Impact upon aquaculture

The historical production of shrimp from both the wild fishery and aquaculture (shown in figure 4.8) demonstrates clearly that during EN events, both sectors of the industry are favored, while during LN there is a decreased in both of them. After, the

2000 La Niña event, and the epidemic of the White Spot virus syndrome the shrimp aquaculture sector almost collapse. Today, it is in the recovery process and the shrimp culture practices have changed. Impacts of Climate change upon de aquaculture sector would be analyzed during October 2007, in the IX Ecuadorian Congress on Aquaculture, where the following topics would be discussed:

- Impact of changes in precipitation and temperature patterns upon culture zones
- Sea level rise impact upon infrastructure in shrimp ponds
- Problems with the tropicalization of the temperate zones and competition
- Availability of fish meal for feeds under different climate change scenarios

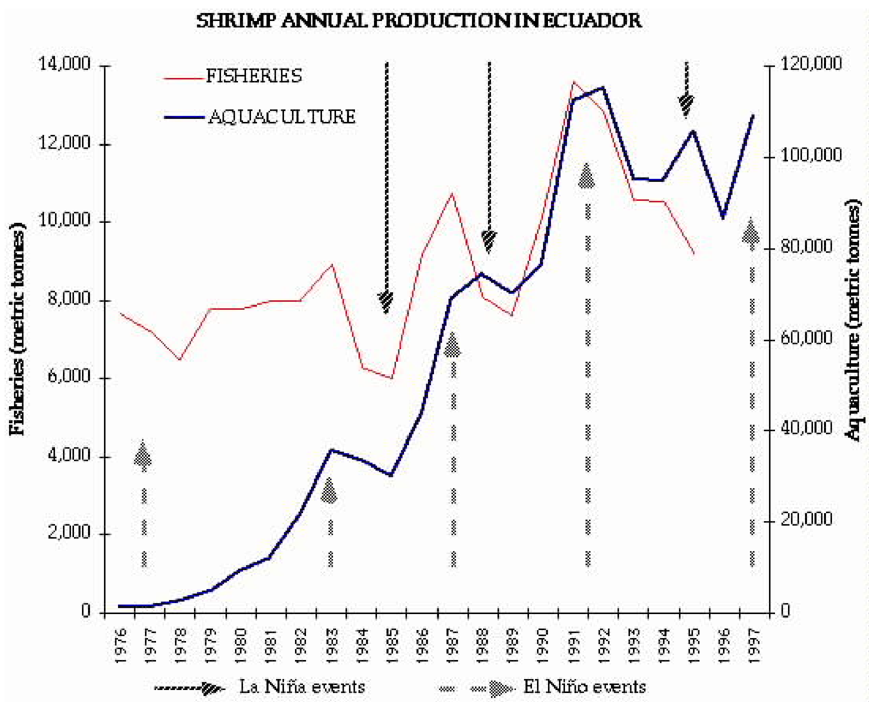


Figure 4.8 Ecuadorian shrimp production from wild fishery and aquaculture sectors.

Warmer water is obviously beneficial to shrimp growth, but may also be related to improved survivals of shrimp in the wild due to a reduction in predation by fish stocks, which tend to decline during EN events. Also, it has been observed in shrimp ponds that mortality due to the white spot virus syndrome reduces under warmer than normal conditions.

5 Potential Local adaptation responses at household, community and national levels

The potential local adaptation responses at different levels would depend on the sociopolitical stability and the cultural aspects of each region. In most communities social capital (human resources and their interactions) is at a level such that community actions could lead to better awareness and preparedness for El Niño events and hence climate change.

In pre-Columbian Ecuador, local coastal settlements were able to cope with extreme events. Albarradas, a U-shaped detention ponds, were build on semi-permeable soil to turns excessive moisture during ENSO warm event years into advantage by recharging the aquifer for dry years. Today, the albarradas are still in use in coastal southern Ecuador. In 2005-2006, the World Bank funded a project on "Adaptation Strategies to the Environmental and Socioeconomic Impacts of El Niño for Rural Communities in Ecuador and Peru". The results have not been published yet (a internal report is available). Marcos and Cornejo (2006) conducted a series of workshops for this project in coastal rural communities and found out that:

- Adaptation to climate extremes and hazards depends on local governance over their own resources and that this may differ from one community to the next one.
- Some communities are better organized and hence better equipped to take actions by themselves within their financial constraints. Any action or political decision is discussed under an assembly meeting, where elder's knowledge is paid considerable heed. The main constrain of Communes is the lack of money available for their projects.

Adaptation strategies have to be tailored to each community in the provinces, depending on their main activities. Some of the proposed actions that resulted from IPUR (2001) in terms of building, rebuilding and reinforcing infrastructure can also be taking in account.

Responses from local and national government depend currently on the size of the population affected and their ability to demand actions. If we look at table 1.1, and compare the population size of Guayas province along with its schooling rate with

Esmeraldas province, it would be easier to understand why actions by local and national government are faster in Guayas.

Since 2005, the Ministry of Environment, through the National Climate Commission (CNC in Spanish), has been conducting workshops with the different stakeholders and policy-makers (http://www.ambiente.gov.ec/WEB/Presentacion/FrameSet1.html) to promote the development and adoption of adaptation strategies in different socioeconomic sectors. During these workshops several adaptation measurements have been proposed that could be applied to any of the coastal landing places. The adaptation measurements proposed for the lower Guayas river basin and Gulf of Guayaquil are:

- Coastal defenses
- Dikes on Daule and Babahoyo rivers
- Improvement of shrimp pond walls
- Mangrove forestation
- Ground level elevation through hydraulic backfill
- Drainage, irrigation and infrastructure projects

However, there is not any adaptation scheme proposed for either the industrial nor the artisanal fisheries sectors that would help them cope with a change in the fisheries dynamics. Some changes have already occurred, and only the industrial sector has been able to change fisheries gear to adapt to current pelagic stock and scarcity distribution. Once quantitative scenarios are developed, strategies for loans, relocation and adaptation of the fisheries sector to climate change could be developed, foster and implemented; as well as strategies for sustainable management of the fisheries.

6 Conclusions

The main problem of evaluating the impact of climate change upon Ecuadorian fisheries is that because of insufficient data and incomplete knowledge on the behavior of the different fisheries, it is not possible to quantify them. This reduces our ability to be efficient in promoting adaptation policies at the proper channels.

The CNC has established monitoring programs for physical variables (hydrological, atmospheric and oceanic). PMRC has proposed and analyzed concrete scenarios for 2010 and 2030 that involved reinforcement of policies in coastal management and planning. The CAF has identified the coastal populations, their vulnerability and risks under ENSO conditions. However, we do not have specific scenarios for climate change impact upon the fisheries sector and sub-sectors, neither a proposal for adaptation measurements.

The scenarios presented here for extreme events, under the assumption that climate change impacts would be similar, are incomplete. We need disaggregate information for each of them, so we could determine the climate change impact at the household level.

7 Recommendations

A program for monitoring physical variables has been set up by CNC-Ministry of Environment. It involves the Ecuadorian National Meteorological and Hydrological Service (INAMHI) as the task force coordinator, and other institutions such as the Oceanographic Institute of the Navy (INOCAR).

INP has a database (under recovery) that covers more or less the period 1981 -2006. Research on the different temporal and spatial scales of variability of the Ecuadorian fisheries is lacking.

Several recommendations are in place:

- To determine spatial and temporal scales of variability of the fisheries per sector (artisanal and industrial).
- To quantify the relationships between ENSO extreme events, and the PDO with changes in the fisheries
- To include climate change impacts and adaptations within the coastal management plans
- To evaluate the size of the labor force really involved with the fisheries sector, and model their behavior under climate change impacts

Information to implement these recommendations is available but disperse. The National Secretary of Science and Technology along with the support of the CNC could foster the submission of research proposals that aim at implementing the recommendations. The Ministry of Agriculture and Fisheries must play an important role along with the Ministry of Environment in using this information for policy implementation.

There are few legal instruments for promoting and enforcing adaptation to climate change. These instruments are more related to clean energies, the production of biofuels, sequestration of carbon, and sustainable use of water. In spite of the size of the coastal line, Ecuadorian government has seldom looked at the sea. Little is known about our marine biodiversity and hence what problems could climate change generate in the fisheries. Current changes in the structure of the governmental fisheries sector, its inclusion under the Ministry of Agriculture, and the revision of the mission of the INP are opportunities to develop adequate legal instruments.
Any adaptation plan has to be thought as a business plan that is going to work under the umbrella of sustainable development. Otherwise, the plans would lie down in a library waiting for their implementation

Finally to implement successful adaptation responses, they have to be worked with the stakeholders and other major players, cultural and socioeconomic aspects must be part of the implementation and a clear State Policy on climate change must be supported and enforced.

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